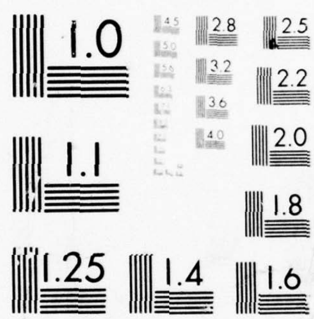
AD-A051 312 HUGHES AIRCRAFT CO FULLERTON CALIF GROUND SYSTEMS GROUP F/G 5/9
PRELIMINARY NTIP SYSTEM CONCEPT AND ALTERNATIVE CONFIGURATIONS.--ETC(U)
JAN 78 N00600-76-C-1352
UNCLASSIFIED FR-77-12-150-ADD NL

1 OF 2
AD
A051 312



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

12

147

HUGHES
HUGHES AIRCRAFT COMPANY
GROUND SYSTEMS GROUP
FULLERTON CALIFORNIA

NAVY TECHNICAL INFORMATION PRESENTATION PROGRAM

TASK 3 REPORT (CDRL A003)

PRELIMINARY NTIP SYSTEM CONCEPT AND ALTERNATIVE CONFIGURATIONS

ADDENDUM—CONCEPT OF THE USER-DATA MATCH MODEL

Submitted by
NTIP Project, Hughes-Fullerton
to
David W. Taylor Naval Ship R&D Center (Code 1803)

Contract N00600-76-C-1352
27 January 1978

Task 3 Report (CDRL A003)

6 Preliminary NTIP System Concept

and Alternative Configurations

ADDENDUM – CONCEPT OF THE USER-DATA MATCH MODEL

Navy Technical Information Presentation Program

11 27 Jan 78

Submitted to

David W. Taylor Naval Ship R&D Center (Code 1803)

15 In Response to

Contract N00600-76-C-1352

12 145 p.

by

Hughes Aircraft Company

Ground Systems Group

Fullerton, California

27 Januarry 1978

14 FR-77-12-150-ADD

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

172 370

AB

CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

SECTION 1
INTRODUCTION AND SUMMARY

1. OBJECTIVES OF THE USER-DATA MATCH MODEL

The user-data matching process is aimed at alleviating the basic shortcoming of TMs – their failure to provide technical information in a fashion which most closely matches the unique requirements of the equipment and the user. As part of this process an initial user-data match can be performed during the NTIPS TM acquisition (specification) effort, which would serve to direct the overall process toward the most effective TM design.

Because of increasingly complex equipment design and the use of modern technologies, technicians depend heavily on the TM to operate and maintain their equipment. In the past, the technician was often able to "ad lib" the required repair because most equipment/systems were relatively simple in nature. Today this is no longer possible. If the necessary technical information, in a suitable form, is not contained in the TM, the technician virtually cannot perform his job satisfactorily. Evidence as well as intuition indicates that the trend toward increasingly more complex equipment/systems will continue to gain momentum through the 1980's. Thus, it is imperative that the TM needed to support the Fleet be as perfectly matched as possible to the users.

Reasons for Present Deficiencies – NTIPP research as well as the research of others indicate that most technicians believe their technical documentation has serious deficiencies and is often difficult to use. Many of the deficiencies cited are due to one or more of the following: 1) Inadequate task instructions, 2) poor quality of presentation modes, 3) an inadequate balance of "what to do," "how to do," and "why," 4) reading comprehension levels not matched to user's abilities, 5) lack of standardization in TM terminology and format, and 6) TMs are often too difficult to use due to environmental factors. It is believed that an effective total solution to these problems cannot be achieved without undertaking a comprehensive, uniform approach. Evidence indicates that most attempts to date at solving TM problems have been singular in nature, attacking one problem at a time. Experience has shown that often the cure of one symptom alone usually leads to additional problems elsewhere. Therefore, the approach taken is one wherein all of the variables or problem areas are addressed simultaneously.

Scope of Total User-Data Matching – Total user-data matching (i.e., initiated during TM acquisition, and performed throughout the content generation effort) would require a continuous and somewhat iterative process that would provide for increasing refinement of the user-oriented TM design and development. The data requirements for this process include personnel characteristics, equipment characteristics, characteristics of the working environment, and identification of the maintenance/operator tasks. These data would be acquired, at various stages of the procurement cycle, from: 1) the hardware acquisition project office, 2) as a result of initial ILS analysis performed by the equipment procurement activity, and 3) through the detailed ILS analysis performed by the contractor. The result of this activity would be TM specifications which govern TM media and document types, presentation components and/or presentation systems, and content, all leading to a detailed TM bookplan (product plan).

Need for Early NTIPS User-Data Matching – The user-data matching process can be initiated at a point in time well before the availability of detailed task analysis data. Early in the TM acquisition phase, data will be available which will permit the determination of the ultimate TM user (i.e., the rating), the environment in which the TM will be used, and the categories of maintenance/operator tasks that correspond to the equipment components involved in the procurement. This information is what is required in order to apply specifications governing media and presentation methods for the procurement. These specifications constitute the

the inception of the process which, when carried through the content-generation phase of the procurement cycle, will result in total matching of the TM to the unique requirements of the user.

The importance of initiating this process as early as possible in the procurement cycle should be emphasized. By identifying the most appropriate development strategy at the earliest possible time, the possibility of a redirection of effort is minimized, and a greater proportion of the development time can be spent on refinement of the appropriate strategy rather than on reformulation of the approach.

Concept of the User-Data Match Model – To provide the early guidance, it would be possible to identify the categories of maintenance tasks from a simple equipment breakdown and knowledge of the rating involved, if data were available relating type of equipment to tasks based on past procurements. From this, the most appropriate presentation method(s) could be determined, as first-cut recommendations, if data were available relating the task categories to presentation methods, based on known human factors principles. It is the purpose of the user-data match model (see next topic) to enable these relationships to be found by using simple matrices of the data necessary to each step.

1.2 APPROACH TO CONSTRUCTION OF THE MODEL

The model consists of three matrices, which can be used to determine types of tasks, associated presentation methods, and required features of the media. The matrices are based on historical analysis of tasks (e.g., NOTAP data), human factors studies, and field surveys.

There is a logical progression of events when the Navy decides to purchase a new system or piece of equipment. First, the Navy specifies that the system/equipment must fulfill some operational requirement. This being so, the mission and function of the equipment are known since the procurement cycle was presumably set in motion to meet the operational requirement. If the function is known, the design specifications which govern the equipment's capability to fulfill the mission are also known. If these design specifications are known, the tasks required of the users will also be predictable from the maintenance history on the components of that equipment.

Since the Navy has a tightly defined hierarchy of tasks allotted to specific ratings, it follows that the equipment governs the selection of the rating who will operate and maintain that equipment. Even among the more sophisticated ratings, there is a clear understanding of the lines of demarcation that limit the equipments each rating will operate and maintain.

To pursue the logic further, if the mission and function of the equipment are known, the Navy has a clear notion of where that equipment will be used so the environment and location are also defined in general terms.

Thus, the three most critical inputs to a user-data matching scheme, equipment type (and main components), personnel characteristics, and environment, will be specifiable to a great extent early in the technical information acquisition process. What is needed is a model to employ these inputs for the selection of optimum methods for presentation of technical information.

As can be seen in Figure 1-1, prior to entering the model there is a requirement for a preliminary equipment breakdown, to identify the main hardware components of the system or unit. This enables a comparison with typical units having a known maintenance history. The breakdown would be based on preliminary design data available to the TM Acquisition Subsystem.

Given the rating and equipment units, the first matrix of the model can be used to identify the categories of maintenance task that are likely to be involved in the procurement. These matrices are unique to each rating, and are developed largely on the basis of analyses of Navy Occupational Task Analysis Program (NOTAP) data. These data indicate, for a given rating, the tasks which are usually performed by the rating as well as the approximate percentage of maintenance time spent performing each task. This information is used to derive the task actions which comprise the horizontal axis of the first matrix. Thus, given the equipment breakdown it is possible to predict the task-actions characteristic of the equipment for the rating involved.

Note that these task actions are not a complete maintenance task statement (i.e., they do not denote a specific action on a specific equipment item). Rather, they are the fundamental activity (e.g., adjust, calibrate, inspect, etc.) of a complete NOTAP maintenance task statement (e.g., "replace" the oil filter on the fork lift). It is assumed that the appropriate presentation of a task action will be similar for all levels of equipment complexity, despite the fact that the content of the task action changes from level to level.

The second matrix indicates, for the given task actions to be presented in the TM, those presentation methods (e.g., photograph, exploded view, directive text,

etc.), or combinations of methods which are most effective in presenting the information to the given rating. Each matrix is unique to a rating. The presentation methods included in this matrix are based on a literature search of the more fundamental presentation "components" currently in use in the services. The presentation "systems" such as JPA, MDS, work packages, FOMM, etc., are not addressed as such in the preliminary version of the model, but are not incompatible with it. The present intent of the model is to asist in the presentation of all types of TM content, both conventional and task oriented.

The presentation components derived from the use of the presentation matrix are provided as recommendations to the TM specification function. A scheme is provided to grade the degree of validity of each recommendation. For example, when more than one presentation component is recommended for the same task action, the user can tell what method of substantiation applies (whether based on analytical judgement, field experiments, etc.).

The last matrix in the model, on media characteristics, applies to all ratings, and relates the characteristics of the users' environment to the physical characteristics of media best suited to that environment. The data on environment and media choices is based on both literature searches and field surveys.

Finally, it must be pointed out that this model will not serve to provide recommendations at the "page level." That is, recommendations would not indicate the specific location of presentation components within a given TM bookplan. Rather, the model indicates the application of presentations components to task actions wherever those tasks actions are deemed appropriate by the content generator.

An adjunct to the model is a list of presentation principles based on human engineering considerations. This is a compilation of general principles which may be applied to the presentation of technical information. Recommendations are made regarding components, formats, media, and physical characteristics of presentation methods. These principles are organized in eight categories: indexing, physical characteristics, typography, reading speed, development of text, graphics, environment, and microform. The list of principles and the references used in its compilation are presented in Topic 2-C-2 of this report.

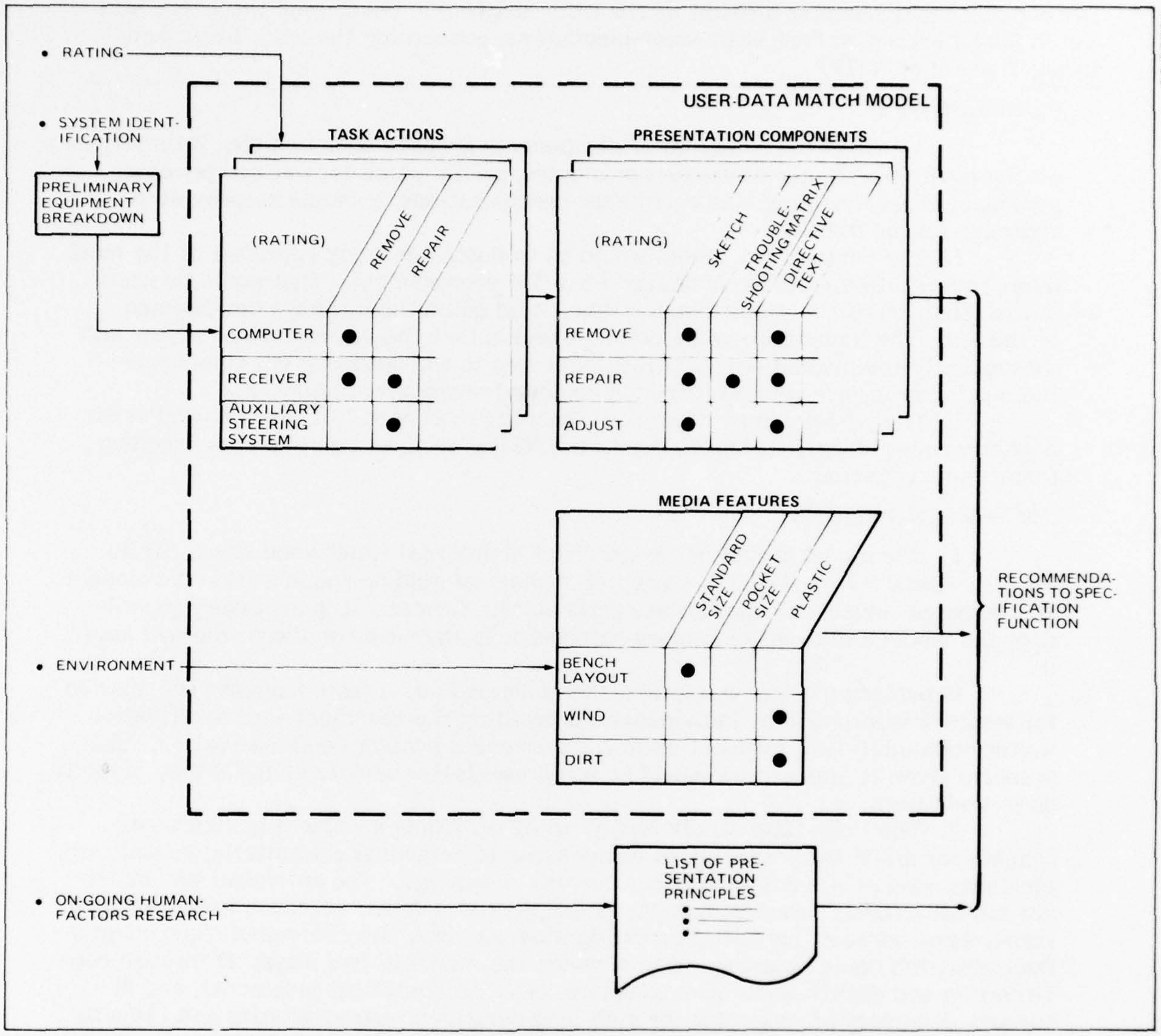


Figure 1-1. Main Elements of the User-Data Match Model. This model enables a "first-cut" recommendation of presentation methods for a TM early in the program before detailed task analyses are completed.

1.3 CONCLUSIONS AND RECOMMENDATIONS

The conclusions reached as a result of the work involved in developing the User-Data Match Model are listed here with recommendations concerning the work to be done during Phase II of NTIPP.

CONCLUSIONS

1. Although the selection of components is based upon complex interactions among environment, human factors principles, presentation format components, personnel characteristics, and equipment considerations, a simple step-by-step approach can be used.

2. The value of the model would be to enable an early appraisal of the most likely presentation methods indicated for a TM procurement. This would be useful in the selection of the specifications that would quide the ultimate development of the TM. The immediate value of the model is that the specifications writer and subsequently the manual writer will have access to the most current findings on the most appropriate presentation components for any given situation.

3. The model can be used as a research "scorecard." It may be used as an ongoing record of current knowledge in the NTIPP area, to point to areas needing further investigation.

RECOMMENDATIONS

1. The model should be tested under simulated "field" conditions. While the User-Data Match Model is a feasible manner of guiding specification developers and technical writers to appropriate presentation formats, it is necessary to validate the model and to make it more responsive to the needs of those who will apply it.

In performing this validation, the model would be tested against the mission for which it is intended by individuals representing the technical and specification writer communities in terms of ability, experience, training, and motivation. The scenario given to the writers would be a representative sample of tasks they actually do in their work.

2. The User-Data Match Model, while providing a sound organizational scheme for matching presentation components to personnel characteristics and task elements, also points out gaps in our current knowledge. The entries in the model are almost entirely based on analytical judgments. Further research is needed with higher-level sources, including expert opinion, surveys, and controlled experiments. Such research could be expected to enhance the model in two ways: 1) through confirmation and clarification of entries now based on analytical judgments, and 2) through discovery of new rules for matching personnel characteristics and tasks to presentation components. For example, it is not clear how GCT scores or levels of task complexity should affect the choice of presentation components.

3. To accurately specify the physical characteristics of TMs, more must be known about the environments to which the TM will be exposed. A systematic effort should be made to identify these various environments and their locations. The investigation should fully represent the surface, subsurface, air, and shore work stations of the Navy, identifying their similarities and differences. The data generated by this effort would be directly incorporated into the User-Data Match Model.

A concurrent survey should identify physical characteristics of TMs found to be most desirable in each environment. It must be noted that the model is at present only a way of demonstrating the feasibility of a scheme for preliminary user-data matching. Additional evaluation and enhancement would be required before the model could be introduced for routine use. Some of the considerations which must be addressed during the development of the model include its updating in relation to changing technology, and its full potential for utilization early in the systems acquisition process.

SECTION 2
APPROACH TO DEVELOPMENT OF THE MODEL

1. SELECTION OF RATINGS FOR THE USER SAMPLE

A sample of 34 ratings was selected which represents the various kinds of technical manual users in air, surface, and subsurface activities. The selected ratings and rating specialties fall into ten of the Navy occupational fields.

The users (defined as maintenance technicians and operators) with a need for technical information will be the ultimate beneficiaries of the user-data match research in the total NTIP Program. The investigation, therefore, focused on the users' personal characteristics, their jobs, the tasks that comprise their jobs, and the equipment and systems upon which they would work.

Selection of Ratings – Since there are many users in the Navy, it was clear that not all facets of user-related data could be listed. From this large population of users, a representative sample of users were selected which would provide data based on their occupations and the listed requirements and characteristics linked to these occupations. As an entry point, it was noted that the Navy Enlisted Manpower and Personnel Classification and Occupational Standards (NAVPERS 18168D, September 1975) lists the total number of Naval occupations (ratings). It was decided to exclude ratings whose jobs were solely involved with equipment operation since their technical information requirements are less than that of a maintenance technician.

The sample was selected from ratings who serve in the three basic environmental categories: surface, subsurface, and aircraft-oriented maintenance communities. The various types of hardware systems requiring maintenance also influenced the sample selection. Although some researchers have attempted to categorize ratings into groups according to the electrical, mechanical, or flow constituents of the systems they maintain, this approach was found to be impractical. For example, an aviation structural mechanic (AMH) who services wing flaps activated by a fluid-activated cylinder is also concerned with the electronic controls which activate the equipment, the structural mounting, and the mechanical construction of the component parts. Thus, the selection process was for the ratings to represent the various maintenance tasks requiring technical information.

Another criterion for selection was that the sample group should include a range of sophistication in tasks defined by the amount of formal training required for job qualifications.

Using these various criteria, 34 ratings and specialties within the ratings were selected as a representative sample of various skills having a need for technical information. Table 2-1 indicates the selected ratings and occupational fields. Nineteen of the ratings are from the "aviation trades" and 15 are from the "seaborne trades".

Coincidently, two other agencies working in other parts of the NTIP Program also sampled the occupational list but chose a different sample of ratings. One was Dr. T. Powers, who was working on task analyses, and the other was the Hughes NTIPP Fleet Survey team that was conducting a field survey of opinions concerning technical information presentation. A comparison of the ratings selected by the three groups is shown on the right of Table 2-1. The disparities in the three selections are due to the different objectives of the three studies.

Selection of Paygrades – The selection of paygrades within ratings was also an issue in constructing a representative sample. Paygrades E-3, E-4, E-5, and E-6 were chosen as representative of prime users of technical information. E-1 and E-2 paygrades are recruits and apprentices and will not have had exposure to the technical documentation at issue. Paygrades E-7 and up are primarily supervisors and administrators, and they do not become involved with day-to-day maintenance except in emergencies.

TABLE 2-1. COMPARATIVE TABLE OF RATINGS SELECTED BY ANACAPA, HUGHES, AND POWERS

	Rating*	Rating Specialty*	Rating Specialities Used by Hughes Survey Team**	Ratings Used by Dr. Powers***
1.	Aviation Boatswain's Mate	ABE (Launching & Recovery Equip.)	ABE	–
2.	Aviation Boatswain's Mate	ABF (Fuels)	ABF	–
3.	Aviation Boatswain's Mate	ABH (Aircraft Handling)	–	–
4.	Aviation Machinist's Mate	ADJ (Jet Engine Mechanic)	ADJ	
5.	Aviation Machinist's Mate	ADR (Reciprocating Eng. Mechanic)	–	X
6.	Aviation Electrician's Mate	AE	AE	X
7.	Aviation Struc. Mech.	AME (Safety Equipment)	–	
8.	Aviation Struc. Mech.	AMH (Hydraulics)	–	X
9.	Aviation Struc. Mech.	AMS (Structures)	AMS	
10.	Aviation Ordnanceman	AO	AO	X
11.	Aviation Fire Cont. Tech.	AQ	AQ	X
12.	Aviation Supp. Eqt. Tech.	ASE (Electrical)	AS	
13.	Aviation Supp. Eqt. Tech.	ASH (Hydraulics & Structures)	–	X
14.	Aviation Supp. Eqt. Tech.	ASM (Mechanical)	–	X
15.	Aviation Electron. Tech.	AT	AT	X
16.	Aviation A/Sub. Warf. Op.	AW (Acoustics)	–	
17.	Aviation A/Sub. Warf. Op.	AW (Helicopter)	–	X
18.	Aviation A/Sub. Warf. Op.	AW (Non-acoustic)	–	
19.	A/Sub. Warfare Tech.	AX	–	X
20.	Boilermaker	BR	(BT)	(BT)
21.	Construction Mech.	CM	–	X
22.	Data Systems Tech.	DS	DS	X
23.	Electronics Tech.	ETN (Communications)	ET	X
24.	Electronics Tech.	ETR (Radar)		
25.	Electron. Warf. Tech.	EW	EW	X
26.	Fire Control Tech.	FTB (Ballistic Missile Fire Control)		
27.	Fire Control Tech.	FTG (Gun Fire Control)	FT	X
28.	Fire Control Tech.	FTM (Surface Missile Fire Control)		
29.	Gunner's Mate	GMG (Guns)	GM	X
30.	Gunner's Mate	GMM (Missiles)		
31.	Missile Technician	MT	–	X
32.	Sonar Technician	STG (Surface)	ST	X
33.	Sonar Technician	STS (Submarine)		
34.	Torpedoman's Mate	TM (Technician)	TM	X

*From Manual of Navy Enlisted Manpower and Personnel Classification and Occupational Standards. Section I: Navy Enlisted Occupational Standards, NAVPERS 18068D, September 1975.
**Also AZ, EM, EN, HT, IC, IM, OM, MN, RM, DR.
***Also QM, SM, OS, RM, DP, MM, EN, MR, EM, IC, HT, TD.

1. SELECTION OF RATINGS FOR THE USER SAMPLE (Continued)

Refinement of the Sample – During the course of investigation, modifications were made to the composition of the sample of ratings. Additions were made when it became apparent that many user-data problems were prevalent among the engineering trades, yet these trades were only marginally represented in the original sample. As a consequence, the electricians mate (EM), the engineman (EN), the hull technician (HT), and the machinists mate (MM) were added to the sample.

A number of deletions were also made. The aviation antisubmarine warfare operator (AW) was deleted from the list when it became clear that his maintenance activities were rare and minor, contrary to earlier indications. The rest of the deletions were specialties within ratings. For example, the STG and STS specialties were reduced to the more general ST rating. These reductions were made for two reasons. First, it was found that the specialties within ratings were fairly similar in terms of their tasks and abilities. Second, most of the other researchers and data sources associated with NTIPP have not used specialties within ratings, so inforamtion was not available at this level of specificity.

The modified list of 23 ratings is shown in Table 2-2.

TABLE 2-2. LIST OF 23 RATINGS REPRESENTING MODIFIED SAMPLE

1.	AB	Aviation Boatswain's Mate
2.	AD	Aviation Machinist's Mate
3.	AE	Aviation Electrician's Mate
4.	AM	Aviation Structural Mechanic
5.	AO	Aviation Ordnanceman
6.	AQ	Aviation Fire Control Technician
7.	AS	Aviation Support Equipment Technician
8.	AT	Aviation Electronics Technician
9.	AX	Aviation Anti-Submarine Warfare Technician
10.	BT/BR	Boiler Technician/Boiler Maker
11.	CM	Contruction Mechanic
12.	DS	Data Systems Technician
13.	EM	Electrician's Mate
14.	EN	Engineman
15.	ET	Electronics Technician
16.	EW	Electronics Warfare Technician
17.	FT	Fire Control Technician
18.	GM	Gunner's Mate
19.	HT	Hull Technician
20.	MM	Machinist's Mate
21.	MT	Missile Technician
22.	ST	Sonar Technician
23.	TM	Torpedoman's Mate

*(Specialties within the rating not shown, e.g., FT(B), FT(G).)

2. RANKING OF RATINGS BY APTITUDE TEST SCORES

Ratings differ greatly in their average test scores on the General Classification Test (a test of verbal reasoning ability) and the Arithmatic Test. Typically, the superior scores are those of the electronics-oriented ratings.

To assess the personnel characteristics of the rating used in the User-Data Match sample, data were gathered from the following sources: 1) the NTIPP Fleet Survey, 2) the Bureau of Naval Personnel Enlisted Master Tapes, and 3) the Navy Occuptational Task Analysis Program (NOTAP). The Fleet Survey, conducted by Hughes, identified a number of important problems related to technical data usage through interviews with over 400 individuals in technical ratings. The data from the BuPers enlisted master tapes* provided statistics on age, sex, race, number of enlistments, and so forth for all ratings and paygrades over the last several years.

The Navy Occupational Task Analysis Program (NOTAP) collects information that determines the job content of Navy billets. This information, collected through the administration of occupational questionaries (job task inventories), is processed by computers, analyzed, and maintained in the occupational data bank. While the task analysis data was in itself of interest to the NTIP Program, the preliminary sections of the NOTAP response packet were particularly valuable in the compilation of data on personnel characteristics. These preliminary sections contained, among other items pertaining to individuals' backgrounds, questions regarding scores received on the Navy Basic Test Battery administered to all recruits, and questions about individuals' opinions regarding need for job training and experience. These two categories of information, abilities at entry, and knowledge gained after entry, were judged to be ideal in the development of the User-Data Match Model.

Interpretation of Test Scores – The Basic Test Battery test scores received from NOTAP are Navy Standard Scores. These are termed standard scores because. regardless of the number and difficulty of the items making up the test, all are placed on the same numerical scale and can be readily compared with each other. Navy standard scores may be interpreted as follows:

- Scores above 64 are "high" and include about 7% of all enlisted personnel.
- Scores from 55 to 64 are "above average" and include about 24% of all enlisted personnel.
- Scores from 45 to 54 are "average" and include about 38% of all enlisted personnel.
- Scores from 35 to 44 are "below average" and include about 24% of all enlisted personnel.
- Scores from 22 to 34 are "low" and include about 7% of all enlisted personnel.
- On current batteries, very high scores (about 70) are rarely found, and scores are not lower than 22.

*Provided to Anacapa Sciences, Inc., via Dr. T. Powers, University of Maryland.

The General Classification Test (GCT) - This test measures ability to learn and think as demonstrated in understanding of relationships between words and ideas. It is principally a measure of ability in the area of verbal reasoning. Figure 2-1 shows average score by rating on the General Classification Test for the 23 representative ratings selected for use in the User-Data Match research. In this figure, the averages are combined across pay grades so that the ratings may be compared. Noteworthy is the large disparity between the two ends of the ranked list of ratings. While each rating has a mean score of at least "average" (above 45), the DS, ET, and other electronics-oriented ratings on the high end of the scale show clearly superior performance on this test. This does not indicate, or course, that the acquisition of a particular rating casues one to become more proficient in understanding words and ideas. On the contrary, since these tests are taken by recruits before the acquisition of a rating, it is the scores on the test which cause recruits to be placed in certain ratings. A correlation comparing electronic vs nonelectronic ratings on their GCT scores results in a coefficient of 0.84, indicating a marked tendency for high scores on the GCT to pertain to electronic type ratings. (See Appendix A.)

While the GCT is not an IQ test, it does correlate well with reading ability ($r = 0.72$). The correlation of GCT scores from NOTAP and those from BuPers tapes is $r = 0.94$. This strong agreement lends augmented credibility to the NOTAP sample data. The large disparity of GCT scores across ratings is an indicant that different ratings may need different forms of technical information presentation.

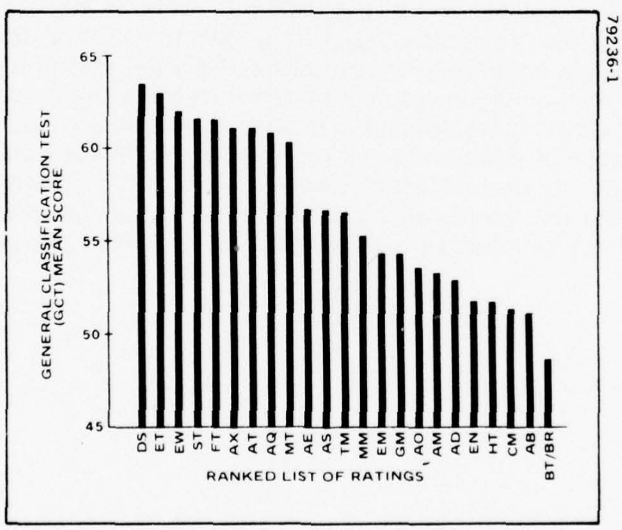


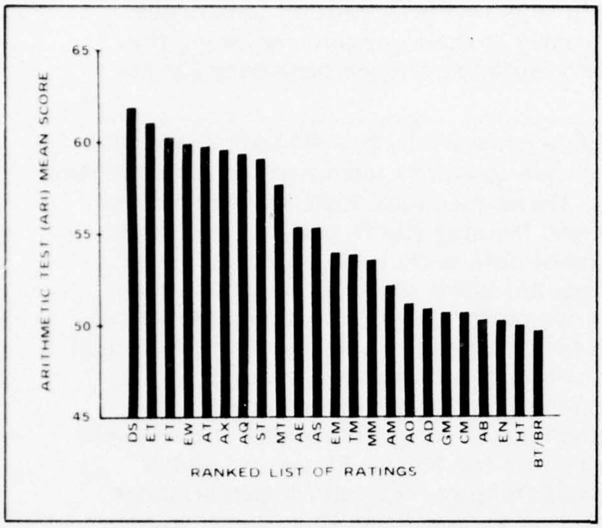
Figure 2-1. Average Score by Rating on the General Classification Test (GCT). The GCT is not an IQ test but measures the ability to learn and think by requiring an individual to demonstrate an understanding of the relationships between words and ideas.

2. RANKING OF RATINGS BY APTITUDE TEST SCORES (Continued)

The Arithmetic Test (ARI) – This test measures ability to use numbers in practical problems, including the ability to perform arithmetical computations and to reason in arithmetical terms. The average scores on the arithmetic test, listed by rating, are shown in Figure 2-2. Notice that this ranked list of ratings appears extremely similar to that for the GCT scores. In fact, there is a very high Pearson product-moment correlation ($r = 0.98$) between the two tests for the listed ratings. These differential abilities in the use of numbers in practical problems across ratings is a factor which should be considered in the choice of technical information presentation methodologies. For example, while some ratings might best derive arithmetical information from a formula or graph, others may need a matrix of pre-solved arithmetical conclusions.

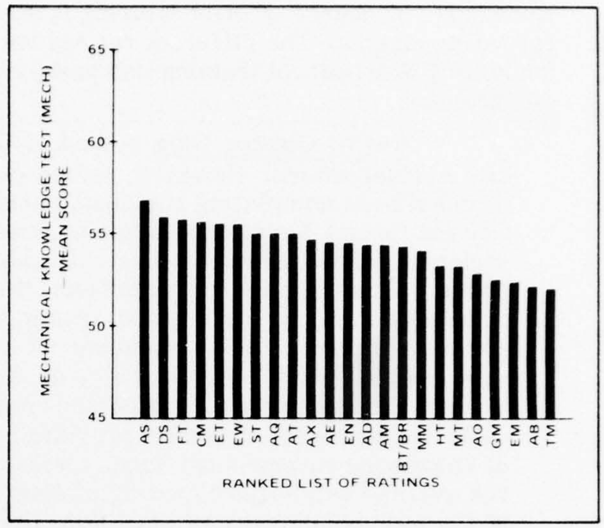
The Mechanical Knowledge Test (MECH) – This test measures familiarity with mechanical tools, operations, and principles. The average score on the MECH, listed by ratings, is shown in Figure 2-3. Notice in this ranked list of ratings that the difference in average scroes across ratings is not particularly great, especially by comparison with the GCT and ARI. This lack of variability is probably due to the fact that the MECH is not a mechanical aptitude test but simply a scale of familiarity with mechanical tools operations and principles, which is measured at entry to the Navy. Since this test does not correlate highly with any other personnel index, nor does it allow for discriminations between ratings, little use may be made of this data.

Figure 2-4 shows the average scores by pay grade on the general classification test, the arithmetic test, and the mechanical knowledge test. It is noteworthy that the variability across pay grades is very small as compared with the variability across ratings shown in Figures 2-1, 2-2, and 2-3. This finding indicates that it is probable that the greatest payoffs in development of different information presentation methods would be from selection of presentation methods based on different ratings than on different pay grades within the same rating. This is a fortunate finding since, it would be much more economical to vary the presentation methods by type of equipment and expected rating involvement, rather than having for example, several different manuals for the same piece of equipment to be used by different pay grades within a rating. This does not mean, however, that allowance should not be made for various skill levels across pay grades.



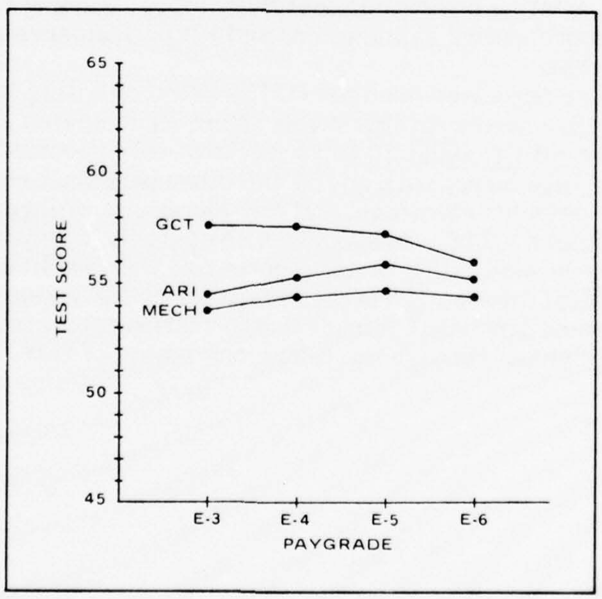
79236-2

Figure 2-2. Average Score on the Arithmetic Test (ARI), Listed by Rating. The ARI measures ability to use numbers in practical problems, including ability to perform arithmetical computations and to reason in arithmetical terms.



79263-3

Figure 2-3. Average Score on the Mechanical Knowledge Test (MECH), Listed by Ratings. The MECH measures familiarity with mechanical tools, operations, and principles.



79236-4

Figure 2-4. Average Scores, by Paygrade, on the GCT, ARI and MECH. Variability across paygrade is very small as compared with the variability across ratings.

3. ANALYSIS OF NAVY TRAINING AND EXPERIENCE REQUIREMENTS ON RATINGS

Knowledge of degree of prior training is useful in selecting presentation techniques for rating classes. The different ratings vary greatly in their opinions regarding the **amount** of Navy school training and years of Navy work experience necessary for job performance.

Rating Opinion Data – Most of the data provided by the NOTAP survey were of a factual nature. However, responses to three questions were based on the opinions of individuals completing the questionnaire. These questions dealt with the necessity for formal Navy school training, on-the-job training (OJT), and Navy work experience. A problem in dealing with this kind of data is that the origins of these opinions cannot be clearly specified. One does not know whether the estimate of necessary weeks of Navy school training for job performance is based on the actual amount received by the respondent, or upon his independent judgement that he might have needed half as much or twice as much training as he actually received. The same difficulty applies to perceived requirements for Navy work experience and OJT. Nevertheless, this data provides a unique opportunity to evaluate the amounts of knowledge ratings must acquire after entry into the Navy. Figure 2-5 shows the average estimates by rating of Navy school training required for performance of the individual's present job. Note the extreme variability in this figure, where estimates of required school experience range from 50 weeks down to about five weeks. The electronics-oriented ratings tend to describe themselves as needing more Navy school training than the other ratings. In fact, a point-biserial correlation yields a coefficient of 0.73, indicating a strong relationship between rating and perceived need for Navy school training. This data may be useful in selecting technical information presentation techniques inasmuch as it provides an index of the amount of school-earned sophistication within a rating. It may be supposed, for example, that a rating having minimal Navy school training requirements will need the most comprehensive explanations and job performance aids for use with unfamiliar equipment.

The average perceived need for OJT is listed by rating in Figure 2-6. Notice the lack of variability across ratings in this figure as compared with the previous one. Regardless of rating, about 20 to 30 weeks of OJT is considered mandatory. OJT does not correlate highly with any of the other personnel characteristics. Nor does it differ between electronic and non-electronic ratings (point-bisearial) correlation coefficient = 0.06). In summary, the perceived requirement for OJT does not vary greatly with rating or test scores and thus has little bearing on the selection of technical information presentation forms for various ratings. It does indicate, on the other hand, that technical information presentation should be such that is aids the individual through the fairly long period of OJT.

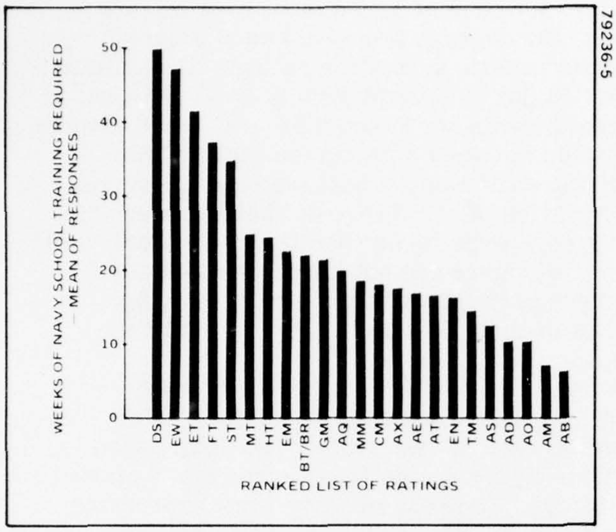


Figure 2-5. Opinion of the Average Navy School Training Required. Study participants were asked "In your opinion, based on your personal experience, how many weeks of Navy school training are required to prepare you for your present job?"

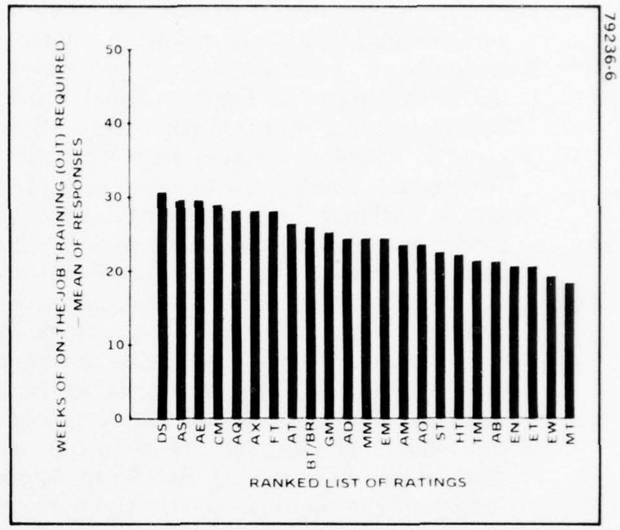


Figure 2-6. Opinion of the Average On-the-Job Training (OJT) Required. Study participants were asked, "In your opinion, based on your personal experience, how many weeks of on-the-job training are required to become functional in your present job?"

3. ANALYSIS OF NAVY TRAINING AND EXPERIENCE REQUIREMENTS ON RATINGS (Continued)

Opinions of the average Navy work experience believed to be required are summarized by ratings shown in Figure 2-7. The average preceived need progress from about two to about four years and varies greatly across the ratings. It is interesting to compare this figure against those portraying ratings ranked by GCT, ARI, and school training required (the correlation coefficients are -0.59, 0.56, and -0.40, respectively). There is a strong negative relationship between a perceived requirement for general Navy work experience and the degree of Navy school training and scores on the aptitude tests. A point-biserial correlation of -0.56 reveals that the electronic ratings feel much less need for Navy work experience than their non-electronic counterparts. While all the implications of this figure are not clear, one aspect for consideration is that technical information presentation should be greatly improved in order to benefit the ratings earlier in their careers so that the requirement for Navy work experience is reduce.

Figure 2-8 following shows the average estimates by pay grade of Navy work experience, OJT, and Navy school training required for the performance of individuals' present jobs. Notice that as in the case of test scores, the progression of data points over OJT and Navy school training for the various pay grades is much less than the range shown by the various ratings. The case of Navy work experience estimated to be required is an exception. While the E3s, E4s, and E5s do not vary greatly in this respect, the E6s estimate a far greater number of years are required for performance of their (mostly by that time, supervisory) jobs. Again, these findings may be taken to indicate that a variation in forms of technical information presentation may be primarily directed at the different ratings and secondarily at pay grades within ratings.

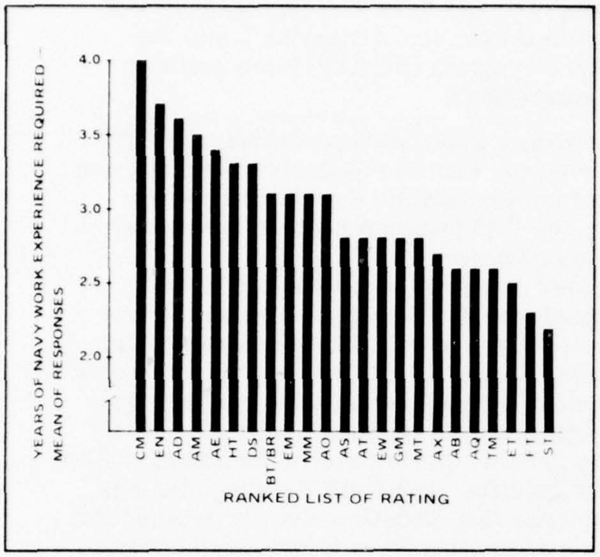


Figure 2-7. Opinion of the Average Navy Work Experience Required. Study participants were asked, "In your opinion, based on your personal experience, how many years of general Navy work experience is required to prepare you for your present job?

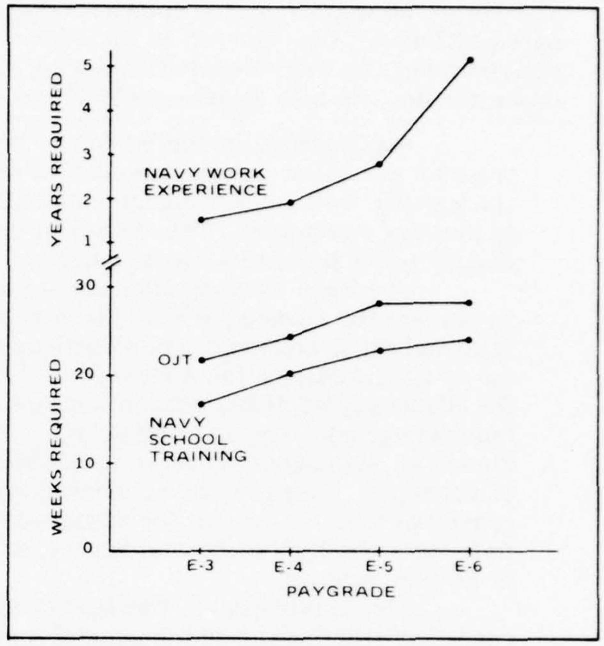


Figure 2-8. Training Required for Performance of Present Job. Average estimates, by paygrade, of Navy work experience, OJT, and Navy school.

1. MAINTENANCE TASKS DATA SOURCES

The Personnel Qualifications Standards (PQS) program, the Rate Training Manuals prepared by BuPers, the research of Dr. Powers at the University of Maryland, and the data banks of the Navy Occupational Task Analysis Program (NOTAP) were useful in understanding the task requirements of the various ratings.

Publications producted under the Personnel Qualifications Standards (PQS) program are based on a special kind of task analysis with the objective of identifying the specific skill and knowledge elements needed to maintain a particular system or piece of equipment. The overall thrust of the PQS program is to define the criteria by which personnel can be qualified on specific systems.

The Rate Training Manuals are designed primarily to aid the technician to prepare for advancement to his next paygrade level. They are based on the professional requirements or qualifications specified in NAVPERS 18068 (Series – Manual of Qualifications for Advancement). Unlike the service or military requirements for advancement, these publications are specific for paygrades within each rating (and rating specialty) and discuss skills and knowledge in terms of technical understanding. Although they refer to specific equipment, this is done to provide examples of concepts. They are not considered system specific. The Rate Training Manuals proved particularly useful for enhancing understanding of data collected by Anacapa, data from the Hughes Special Survey, and in extrapolting from information provided in Powers' reports.

The University of Maryland research effort conducted by Dr. T. Powers for DTNSRDC identified the general kinds of job tasks performed in conjunction with technical manual use which are common to most (if not all) Navy technical ratings (Powers, 1977)[16] Dr. Powers formed his data base from two sources: NOTAP and a data-collection effort at a series of Naval establishments. These findings, though on a somewhat different sample of ratings, were useful to compare with the Anacapa task analyses.

The most valuable source of rating-specific task data was the Navy Occupational Task Analysis Program (NOTAP). As discussed earlier, the NOTAP program determines the job content of Navy billets through the administration of occupational questionnaires (job task inventories). These data are processed into a computerized data bank, and may be printed out in various formats, such as percentages of time spent on the itemized task categories. The printouts supplied for each rating were invaluable to the analysis in that they listed the tasks done in detail. This permitted the examination of the amount of time each rating spent on different types of hardware, performing different types of tasks, at different levels of complexity.

Useful data came from an analysis of NOTAP printouts obtained from the Career Task Development Group at the Chief of Naval Education Training Service Support Center Pacific, San Diego (CNETSCPAC). This agency is a central repository and user of NOTAP computer printouts for developing curricula and training programs. These printouts were available in a readily usable form for the selected ratings in the User-Data Match Sample.

[16] Powers, T. E. Selecting Presentation Modes According to Personnel Characteristics and the Nature of Job Tasks. Part I: Job Tasks. Baltimore, Maryland: University of Maryland, January 1977.

The NOTAP printouts provided detailed and specific maintenance activities categorized by equipment types and levels of complexity. This breakdown provided a definitive data base in two categories: 1) a listing of tasks defined by a large sample (range of n = 400-1200) of the users themselves, and 2) a listing of equipment, systems, and components also identified by the users. Because the data in the printouts are categorized by what the actual users say they do, rather than what the Navy thinks they do, the data are valuable in that they reflect the "real-world" situation and are not estimates.

2. DEVELOPMENT OF TASK ACTION DATA BASE

Characteristic task actions for four sample ratings were extracted from the NOTAP survey.

Many kinds of equipments, assemblies, components, and parts are operated and maintained by an equally complex hierarchy of ratings and paygrades at different levels of maintenance. To bring the data base within manageable proportions for the purposes of the model, an analysis was conducted of four representative ratings (MM, ET, AT, AB) to disclose the types of systems they worked with or operated. These four ratings were selected from the sample of 23 ratings used in the User-Data Match research effort. The material comprising the raw data for analysis came from task inventories carried out by the Naval Occupational Task Analysis Project (NOTAP) and summarized in various ways in computer printouts. A large sample from each rating category was surveyed to determine precisely those tasks and equipment types which consitute the "work package" for a specific rating.

The total number of men at the journeyman level for the four sample ratings is shown below, together with the total tasks and the maintenance-related only tasks.

Rating	No. of Subjects	Total Tasks	Maintenance-Connected Tasks
ET	1,265	597	413
AT	768	346	192
MM	1,183	590	410
AB	403	419	207

The intent in analyzing each rating by task and system was to establish a data base on the various levels of maintenance as they applied to various items of hardware. Unfortunately, the respondents to the NOTAP survey did not itemize their work in terms of the type and level of systems on which they worked.

The NOTAP data lists hundreds of maintenance tasks for each rating. There are, however, relatively few task actions performed, these being common to many items of equipment. The NOTAP printouts provided statements of maintenance tasks such as "clean digital computer electronic components," followed by the percentage of rating members performing this activity and the percentage of time their members spend performing the activity (see Table 2-3). Each of the hundreds of task statements pertaining to each rating is divisible into two portions: an action verb (task action) and a particular type of hardware.

It is the large number of equipment items which necessitates a listing of hundreds of maintenance tasks. Typically, the number of task actions required for a given rating is relatively small; approximately 15 to 20 task actions are sufficient to describe a rating's maintenance responsibilities without reference to specific equipment.

The action verbs required to describe the maintenance responsibilities of Navy Technical ratings are defined in Table 2-4. These action verbs, derived from NOTAP data on the four ratings of this study, represent most of the maintenance task actions performed by all Navy technical ratings. Definitions and synonyms are

provided to clarify the semantic difficulties that inevitably arise when words such as bleed and drain, or fill and top-up, are used interchangeably.

The approach used in developing the task action data base is to avoid reference to specific hardware items, and deal simply with the task actions performed by the ratings at a level of hardware complexity. The task action "calibrate", for example, will remain basically the same regardless of the function performed by the equipment to be calibrated. It is recognized, however, that the task action "calibrate" may vary in meaning depending upon the level of complexity of the hardware item. Furthermore the meaning of task actions will vary somewhat with the type of rating performing them, because different ratings maintain different types of hardware.

TABLE 2-3. EXAMPLE OF NOTAP TASK ANALYSIS PRINTOUT

Data Systems Technician (SD) – Journeyman (Paygrade 5 & 6)

Maintenance Task		Performing Task	Percent of Time Spent on Task by Performing Members
Task Action	Type of Hardware		
Clean	Digital Computer Components	53.8	1.7
Adjust	Magnetic Tape Transport	51.8	2.0
Test	Printed Circuit Boards	57.8	1.9
Troubleshoot	Electronic Equipment	80.9	2.0

2. DEVELOPMENT OF TASK ACTION DATA BASE (Continued)

TABLE 2-4. DEFINITIONS OF ACTION VERBS DESCRIBING TASKS

Verb	Definition	Example	Synonym
ADJUST	To bring into a more satisfactory state; to bring from out-of-tolerance to an in-tolerance condition	Adjust voltage output to read 50 VDC. Adjust slot "A" in turn-buckle to coincide with slot "B"	ALIGN
BLEED	To extract from; to release some or all of a substance from its container	Bleed brake fluid from master cylinder	REMOVE
CALIBRATE	To determine accuracy and restore to a special standard	Calibrate VTVM by comparison with master meters	ALIGN
CLEAN	To remove dirt, dust, grease, rust or foreign material from	Clean grease nipples of grit before attaching grease gun	---
DEGAUSS	To demagnetize a substance or equipment	Degauss ship as protection against magnetic mines	DEMAGNETIZE
DISPOSE OF	To get rid of	Dispose of flammable rags by burning	DESTROY
FILL	To put into up to a specified level or to limit of container	Fill battery with electrolyte to bottom of slot in tube	CHARGE TOP-UP
INSPECT	To examine by visual observation of a condition (of a system)	Inspect hydraulic pipe joints for leaks	EXAMINE CHECK
INSTALL	To place in position and attach; to fit an equipment/unit into next larger level of system	Install waveguide on mast, Install generator on truck engine	(Note: Preferred usage is WIRE instead of INSTALL WIRING, similarly CAP and PLUG)
REPLACE	Exchange one piece for another	Replace faulty capacitor in B+ network	EXCHANGE

TABLE 2-4. DEFINITIONS OF ACTION VERBS DESCRIBING TASKS (Continued)

Verb	Definition	Example	Synonym
RIG	To assemble, adjust, and align major components in a system (notably aircraft)	Rig control cables, pulleys, turnbuckles, for airfoil components	PUT TOGETHER FIT
SERVICE	Replenish consumable supplies, preventive maintenance	Service wheel cylinders with HY90 weekly; service air filters on mobile deck equipment	
SET (CODES)	Bring electronic equipment up to operational requirements for identification codes, power output response	Set transponder codes for IFF MK10 Channels 3, 7, 9	
TEST	To perform specified operations to verify if system or equipment is functioning to a standard	Test power output of BQS-13 Sonar at full level	CHECK OUT
TORQUE	To apply turning force to fix a nut or collar more firmly in place	Torque the nut to 60 foot pounds	TIGHTEN
TUNE	To adjust for precise functioning	Tune DF equipment to within plus/minus o.1 Hz	

3. DEFINITION OF LEVELS OF HARDWARE COMPLEXITY

The User-Data Match Model identifies tasks for four levels of equipment complexity: system, equipment, assembly, and part. Because users are inconsistent in their use of words like "system" and "component" to describe their equipment, definitions of these four levels in terms of the "loose" equivalents were established.

In order to apply the task actions to levels of equipment complexity, it is necessary to devise an orderly way of referring to the levels of complexity.

The Navy equipment on which operation and maintenance is performed is commonly referred to as consisting of "systems", "units", "components", "sets", "requirements," and other levels of hardware denoting various levels of complexity. For example, respondents to the Naval Occupational Task Analysis Project (NOTAP) survey described their work in terms of an action work, such as "align" or "calibrate", together with an equipment type or equipment level. It was evident that different groups of action verbs applied to various levels of equipment complexity, but a word like "system" was being used loosely to describe an entire fire control system, or a radar set. The ambiguity of the terms presented a systematic allocation of the task actions to levels of complexity.

A good terminology for distinguishing levels of equipment complexity is already available in the standard nomenclature of logistics items. This is shown in the second column of Table 2-5. A further simplification is possible in that the distinctions between system/subsystem or assembly/subassembly do not generate different contents for the task actions. Thus a 4-level scheme was adopted as shown in the first column.

Analysis of the NOTAP responses showed that the equipment types could be categorized into the four levels of complexity defined in Table 2-5. The characterisitcs, and some of the "loose" equivalents used by the NOTAP respondents are listed in the table for each item, along with some typical equipment examples.

In the User-Data Match Model, recommendations for presentation components to aid task actions are modified by the level of complexity of the hardware involved. Obviously the task elements and actions required for alignment by an ET rating at the component level in adjusting a variable resistor will be quite different from aligning a transmitter and receiver to a common frequency in a complex communication system.

TABLE 2-5. DEFINITIONS OF LEVELS OF COMPLEXITY

Level	Logistics Item	Characteristic	"Loose" Equivalent	Example
Systems & Subsystems	a. System	Complex mission: multiple items		• Air Defense System • Fire Control System
	b. Subsystem	Function or functions contribute to mission: multiple items	• Group • System • Component	• After Steering System • Data Processing System
Equipment	Equipment, Set	Smallest physical entity that performs function(s) along (with only prime power & stimulus)	• System • Unit • Component • Rack	• Radar Set • Computer • Turbine
Assembly	a. Unit b. Assembly c. Subassembly	Physical entity that performs a function or part of a function within an equipment	• Module • Component • Chassis	• Circuit Card • Control Panel • Main Reduction Gear • "Memory Section" • Transmission (Mech)
Part	Part, Piece	Lowest element, usually not repairable	• Component	• Resistor • Diode • Piston Ring • Gear Wheel

1. IDENTIFICATION OF PRESENTATION COMPONENTS

An illustrative set of presentation components (kinds of pictorials, diagrams, etc.) was identified through a search of the literature and Navy TMs.

The approach to presentation techniques was to develop a representative list of the major presentation techniques in use today, based on an examination of TMs in the field. A conventional definition of presentation technique was adopted that was neither excessively detailed nor at the proprietary system level.

Over the years the technical publications community has developed various unique formats for presenting information. Many of these formats were given acronymic identifiers to label their unique feature. These methods of presenting technical information, of course, are tied closely to the maintenance of one type, or family of equipment, to a particular level of complexity of equipment, or even to the recurring problem of short-term enlistments (which is associated with a limited depth of technical ability).

For example, although FOMM and JPAs are very effective developments in their own right, each has some characteristics that precluded it from being used in wide sense for all tasks, systems, and for all users. Some of these characteristics are linked to the actual physical format (size) of the item, and some only apply to maintenance at a simple directive non-deductive level. Many other methodologies exist that can be applied, in the generic sense, to equipments at all levels of complexity. All that is needed is to match the components or basic elements of the presentation technique to specific types of users.

An important step in the research was to develop a checklist to categorize and define the components that were present in the documentation now in operational use in the Navy. The checklist was developed from a review of the literature and an examination of typical technical manuals. The checklist was then used as a means of logically ordering observations concerning formats and components gathered during a field survey. One hundred twenty-five documents were examined in the field representing a wide range of presentation techniques and systems throughout the field. A summary showing the components of each type of presentation was compiled (see Appendix C).

As a result of the field analysis, it was clear that many of the presentation components in the checklist were too specific or defined at too low of a level to be useful in the User-Data Match Model. For example, various distinctions in types of block diagrams, such as a functional block diagram versus data flow block diagrams, were found to be of little value for the purposes of the model. After consultation with the Hughes technical staff, a list of presentation components with conventional definitions and clear-cut examples was developed. The resulting list of 40 presentation components consists of sufficient "building blocks" to form most of the presentation techniques and formats presently used (see Table 2-6). This list would have to be coordinated with the specification modules in the final design of the User/Data Match Model. The User/Data Match Model will provide a method for the selection of these components individually, or in groups depending upon the task actions at different levels of compelxity by various ratings. However, it should be noted that the recommendation of presentation components by the model would not constitute a TM design as a substitute for any of the presentation systems. The application of a presentation sytem (such as FOMM, SPA, SMD, etc) would be a separate determination that would take precedence over the recommendation of any particular presentation component.

TABLE 2-6.DEFINITIONS AND EXAMPLES OF PRESENTATION COMPONENTS

PICTORIAL REPRESENTATION

Portrayal

Figure C-1 Photograph
Figure C-2. Airbrushed Photograph
Figure C-3. Airbrushed Drawing
Figure C-4. Sketch
Figure C-5. Engineering Drawing

View

Figure C-6. Two-Dimensional View
Figure C-7. Three-Dimensional View

View Type

Figure C-8. Assembled
Figure C-9. Exploded
Figure C-10. Cut-Away

Locators/Identifiers

Figure C-11. Superimposed
Figure C-12. Coordinate
Figure C-13. Line and Leader

DIAGRAMMATIC REPRESENTATION

Blocks

Figure C-14. Overall Block
Figure C-15. Detailed Block

Interconnections

Figure C-16. Schematics
Figure C-17. Wiring
Figure C-18. Cabling
Figure C-19. Functional Signal Flow
Figure C-20. Digital Logic

Hybrid Blocks

Figure C-21. Blocked Schematics
Figure C-22. Blocked Digital Logic
Figure C-23. Pictorial Block

Servicing

Figure C-24. Timing
Figure c-25. Maintenance Dependency Charts (MDCs)
Figure C-26. Decision Trees
Figure C-27. Waveforms
Figure C-28. Graphs

TEXT

Mode

Figure C-29. Directive
Figure C-30. Deductive

Style

Figure C-31. Continuous
Figure C-32. Segmented

CONDENSED DATA

Lists

Figure C-33. Retrieval-Oriented LIst
Figure C-34. Glossary/Abbreviations
Figure C-35. Materials
Figure C-36. Wire

Tables/Matrices

Figure C-37. Procedures
Figure C-38. Specialized Data Table
Figure C-39. Specialized Data Matrix
Figure C-40. Retrieval-Oriented Matrix

2. HUMAN FACTORS PRINCIPLES RELATING TO TECHNICAL INFORMATION PRESENTATION

While the User-Data Match Model provides a logical basis for selecting presentations and formats, some considerations do not fit within the parameters of the model and can best be covered by reference to general principles governing information presentation.

In discussing the problem of matching technical information to user requirements, Booher (1975) commented, ..."writers of technical manuals, designers of programmed instructions, and designers of equipment are continually faced with the problem of selecting among pictorial, schematic, and printed formats to communicate information with little or no knowledge of the format's effect on understanding or comprehension of the information being presented." Some basic principles concerning the relationship between man and the information he needs to do his job do exist in human factors literature. While some of these principles may appear basic, they are overlooked frequently enough in technical manual development to warrant their inclusion in the User-Data Match function. These principles are listed in Table 2-7.

A comprehensive review was made of 103 sources of possible reference data that would lead to some generally applicable principles of good presentation. Not every source was fruitful; some were highly specific to equipment or tasks, some were totally focused on the mechanics of presentation, and some were so theoretically oriented that they had no immediate practical application. The documents reviewed are listed in Appendix B.

The statements categorized into the divisions listed in Table 2-7 are framed in directive or conditional terms. If the statement is attributable to a single sourse, an appropriate credit reference is listed. However, many of the statements represent a composite developed from the literature, and therefore cannot be credited to a single reference source.

TABLE 2-7. HUMAN FACTORS PRINCIPLES IN INFORMATION PRESENTATION

PHYSICAL CHARACTERISTICS

- Books should be bound so that pages will lie flat when the book is open (Woodson & Conover, 1964).
- When tabs are used, they should be designed so that they cannot tear out with normal usage (Woodson & Conover, 1964).
- Content tabs and the indents used for thumb indexes should be large enough for legibility and no larger.
- Multipage figures are undesirable.
- Foldout pages should never fold downward into the lap of a user (i.e., foldouts should extend sideways).
- Transparent overlays are an effective means for successively combining or exposing parts of an illustration.
- As the number of color-coded items increases, the value of color as a cue for selecting impartant information decreases.

TABLE 2-7. HUMAN FACTORS PRINCIPLES IN INFORMATION PRESENTATION (Continued)

TYPOGRAPHY

- Ten-point type with the line length ranging from 14 to 25 picas (2-5/16" to 4-3/16") is easiest to read when using a double-column format (Tinker, 1963).
- Black-on-white is 14.7% more legible than white-on-black (Holmes, 1931).

READING SPEED

- Reading speed is greater using proportional spacing than equal space for each letter. (Payne, 1967)
- Reading speed is affected by brightness contrast between ink and paper, rather than the colors of ink or paper alone.
- Reading speed is greater with lower-case text than all-capital text (Tinker, 1955).
- Reading material presented with unjustified right margins can be read slightly faster than justified copy (Powers, 1962).
- Black-on-white is read 16.1% more efficiently than white-on-black (Paterson & Tinker, 1931).

DEVELOPMENT OF TEXT

- Material presented sequentially in logical groupings improves the comprehensibility of a manual.
- Text should be consistent in terminology, style, and format. Use the simplest common words or phrases which convey the intended meaning.
- Technical manuals should be consistent with respect to formatting, abbreviations, capitalizations, nomenclatures, acronyms, numbering and references (Price, 1975).
- Short, precise paragraphs enhance comprehensibility.
- The necessity for cross-referencing should be kept to a minimum.
- Consistency in the choice of words is recommended.
- Important information needed by an experienced high-skill user can be highlighted to enable him to quickly utilize essential information after he is thoroughly familiar with a detailed procedure. Examples of highlighting: underlining, bold-face type, italics, color, and boxing (Department of Defense, 1976a).
- Borders around text materials of critical content are useful for emphasis.

2. HUMAN FACTORS PRINCIPLES RELATING TO TECHNICAL INFORMATION PRESENTATION (Continued)

TABLE 2-7. HUMAN FACTORS PRINCIPLES IN INFORMATION PRESENTATION (Continued)

- For procedures descriptions, the information must be presented in a logical location-item-action indication sequence (Department of Defense, 1976a).
- Text combined with a corresponding illustration enhances comprehension of complex material.
- In a technical manual, all descriptions of warnings, cautions, and notes appearing on the actual equipment should be incorporated into the text.

GRAPHICS

- Learning and comprehension of verbal material by low-aptitude subjects can be enhanced by pictorial presentation (Rohwer, 1967).
- Simplified line drawings are a cost-effective and training-effective method of presenting visual information.
- Illustrations or other types of graphics should be used to enhance or reduce the amount of text.
- Placing the text and graphics together eliminates shifting back and forth between text and supporting figures.
- Graphic titles should accurately and succinctly describe the graphic.
- To prevent clutter the amount of information included in a graphic has to be controlled to present no more than required by the user for task performance.
- Locator diagrams should be used to identify the physical position of components in complex systems or sets of equipment.
- Leader lines should be uniform, short, and as straight as possible.
- Thickness of lines on a graph should represent the order of the importance of the information.
- Length of graph scales, captions, etc., should be in similar proportions for vertical and horizontal axes.
- The number of curves on a single graph should be limited to four to avoid confusing the reader.
- When the general shape of a function is important, a graph is superior to tables or scales.
- When interpolation is necessary, graphs and scales are superior to tables.
- Tables should be designed so that there are more horizontal rows than vertical columns.

TABLE 2-7. HUMAN FACTORS PRINCIPLES IN INFORMATION PRESENTATION (Continued)

- Horizontal lines in a table should be used sparingly and then only for separation of major sections of the table.
- Vertical lines should be used in a table to clarify column separation.
- Standard hazard warning symbology should be used in the manual to coincide with symbols used on operational equipment.
- References which describe controls and displays in text should use the same identifiers as are on the parts themselves or in supporting graphics.
- Exploded views are normally used in removal/installation, assembly/disassembly, repair, and illustrated parts breakdown data.
- Pictures or illustrations should be oriented in the way that the technician expects to see the actual equipment.
- Excessive realistic detail in photographs may be sufficiently strong to detract attention from relevant and important learning cues.
- A legend or key must be incorporated into a graphics presentation (as well as associated text) when index numbers are used as identifiers or locators.
- Cartoons are often an effective means of presenting information since they concentrate on essential detail and exaggerate crucial characteristics of appearance and behavior.

ENVIRONMENTAL

- Sixty foot-lamberts is adequate for reading conventionally-formatted materials, while 300 foot-lamberts is necessary for fine detailed work.
- No work involving reading should be attempted below 30 foot lamberts without supplementary lighting.

MICROFORM

- Text and drawings must be vertically oriented (most viewers cannot be turned 90°).
- Foldouts must be eliminated or designed for single-frame reproduction of contiguous sections, i.e., use white frames around drawn sections ("guttering").
- Halftone graphics must be avoided because of reproduction problems.
- Type size must be selected carefully to fit the several criteria for best results in copying, reproducing, and reading (viewing) methods.
- Integration of text and illustrations is critical.

2. HUMAN FACTORS PRINCIPLES RELATING TO TECHNICAL INFORMATION PRESENTATION (Continued)

TABLE 2-7. HUMAN FACTORS PRINCIPLES IN INFORMATION PRESENTATION (Continued)

- Index must be combined with Table of Contents.
- Use of color is possible but expensive.
- Bibliographic references should be placed on the bottom of the pages on which they occur.
- On the basis of limited studies, positive film (black characters on a clear background) appears to be superior for reading and comprehension (Teplitz, 1970).
- Efficient storage and retrieval of information (in microform) is dependent on the identification of that information in such a way as to permit effective filing and recall by the user (Teplitz, 1970).

1. READABILITY CONSIDERATIONS FOR THE TM USER

A disparity exists between TM readability and the reading ability of Navy enlisted personnel. The predicted reading grade level (RGL) of Navy technicians who actually use TMs ranges from 9 to 13, while the measureable RGL of current Navy TMs varies from 11 to 15.

A great deal has been written on readability of technical manuals and the largely accepted mismatch between this readability and the reading ability of Naval technical personnel. But the assumed degree of the discrepancy between reading ability of Navy technicians and the readability of their technical manuals may be due to the inappropriate application of traditional readability formulas to personnel and manuals for which they were not specifically designed.

The often-cited figures for the readability of Navy technical manuals range from reading grade levels 11 to 15 (e.g., Biersner, 1975). There have been several studies testing the reading ability of Navy technical personnel. In general, this reading ability, or reading grade level, is found to be between 9 and 13 (e.g., Carver, 1973). It is on the basis of such figures that the apparent mismatch between reading ability and readability is founded. It would appear, given the findings, that approximately half of the Navy technical personnel would have difficulty reading their technical manuals (Curran, et al., 1975).

There are several considerations that may mitigate the extent of this mismatch: (1) word familiarity, and (2) reading-operation relationships.

Word Familiarity – Most readability formulas are weighted by "difficult words" (i.e., words outside the normal spoken vocabularly, or words of several syllables). Technical manuals have been shown to contain approximately 15% technical words (Curran, et al., 1975). These words are not found in the normal spoken vocabularly. They are also typically multisyllabic words, such as "omni-directional. The effect of these technical words is that of raising readability scores toward higher levels than if they were not present. This is meaningful in the sense that big technical words are linguistically more difficult, yet, to the Navy electronic technician, "omni-directional antenna" is just as familiar as "preliminary antenna". It has been suggested (Curran, et al., 1975) that a list of common Navy technical terms be assembled that count as simple words in readability formulas.

Reading-Operation Relationships – There is almost no data on the relationship of reading grade level, as measured on a standard reading test, and the ability to actually use technical manuals in an operational situation. According to Githens, et al., (1975), "it may be that skills the technicians use in working with the TM (e.g., finding information, referring back and forth from equipment to text without strict time constrainsts) are different enough from those called for by a standardized reading test (e.g., reading short passages quickly and answering questions) to render the test a doubtful prediction of a technician's actual ability to use the TM." This is not to say that readability indexing is invalid in the Navy situation.

Additional factors that bear upon the "mismatch" may be summarized under two headings: motivation and clarity. None of these factors are adequately accounted for in the application of reading ability or readability tests.

Motivation can certainly affect the amount of effort and attention a technician will put into comprehending a technical manual. His desire to understand the material, his interest in the content, and his familiarity with the subject matter are all important parts of the motivational factor. Of course, readability itself is an important factor in preserving whatever may be obtained by motivation.

Clarity of the prose is another interacting factor. RGL formulas are concerned with length of words and sentences. So far, they do not concern themselves with the grammitical complexity of the prose. Thus, true readability (comprehensibility) may be affected by the grammatical and syntactical factors of the writing style. These areas are currently under study throughout the human factors community.

2. READABILITY FINDINGS INVOLVING TM USERS

Average Reading Grade Level varies considerably over a representative sample of technical ratings, ranging from 9 to 13.

Analysis of the readability issue reveals that most of the Navy reading ability testing programs involve recruits, rather than individuals who have entered a rating via "A" school or another method. Since the vast majority of Navy technical information users are individuals who are eligible for school training, and have been assigned ratings, it is appropriate to examine the composition of these ratings with respect to their mental capabilities, with particular reference to verbal reasoning and reading ability. A first cut at this kind of information was provided by an examination of ratings apportioned into the various mental categories. Such data is available from BuPers statistics, as reported by Powers (1976). While this data showed considerable variation in average mental ability among ratings, it was clear that individuals holding ratings were, in general, more likely to be members of Mental Group Categories I, II, and Upper III than were recruits. This finding is, of course, largely the result of Navy selection and qualification procedures. Mental group categories are determined for individuals by aiding their GCT, ARI, and MECH scores and finding the percentile value (based on all enlisted personnel) of the total. The top seven percentiles of these scores are classified as Group I. The scores in the 65th through 92nd percentiles constitute Group II, and the 49th through 64th percentiles are described as Group Upper III. The 48th percentile and below make up Group Lower III and Group IV; those personnel who do not usually qualify for a "technical" rating.

The Navy Enlisted Occupational Classification System (NEOCS) study included a section (K-IV) by Carver (1974) regarding the correspondence of Mental Categories and Reading Grade Level (RGLs). As a general rule, Mental Categories I, II, III, and IV correspond to RGLs 13, 11, 9, and 7, respectively. Application of this rule to the BuPers statistics on Mental Category distributions across ratings seemed to indicate that the magnitude of the reading ability problem in the technical trades was not as great as had been feared.

A more exacting specification of mental abilities for the ratings of interest was made possible by materials from the Navy Occupational Task Analysis Program (NOTAP). Of particular interest were the General Classification Test (GCT) scores for each of the User-Data Match selected ratings, broken down by paygrades E-3 to E-6. The GCT is a measure of ability in the area of verbal reasoning. This ability varies considerably across ratings, as shown in Figure 2-9.

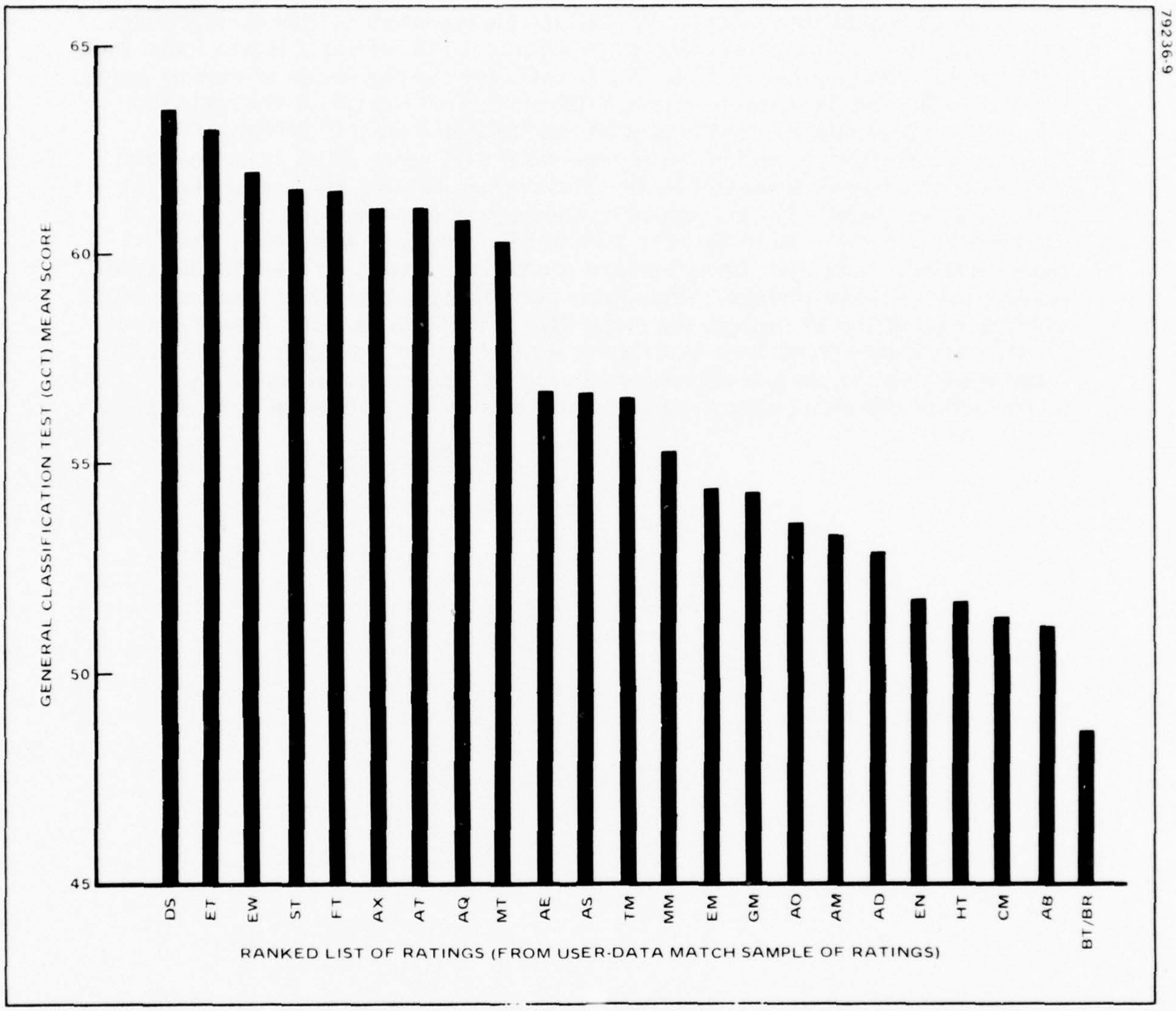
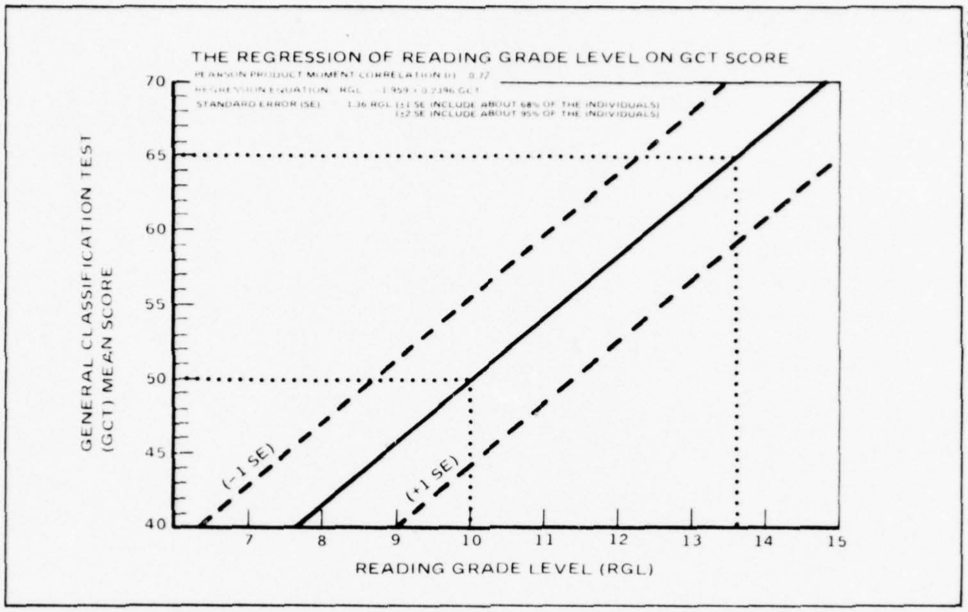


Figure 2-9. Average Score by Rating on the General Classification Test

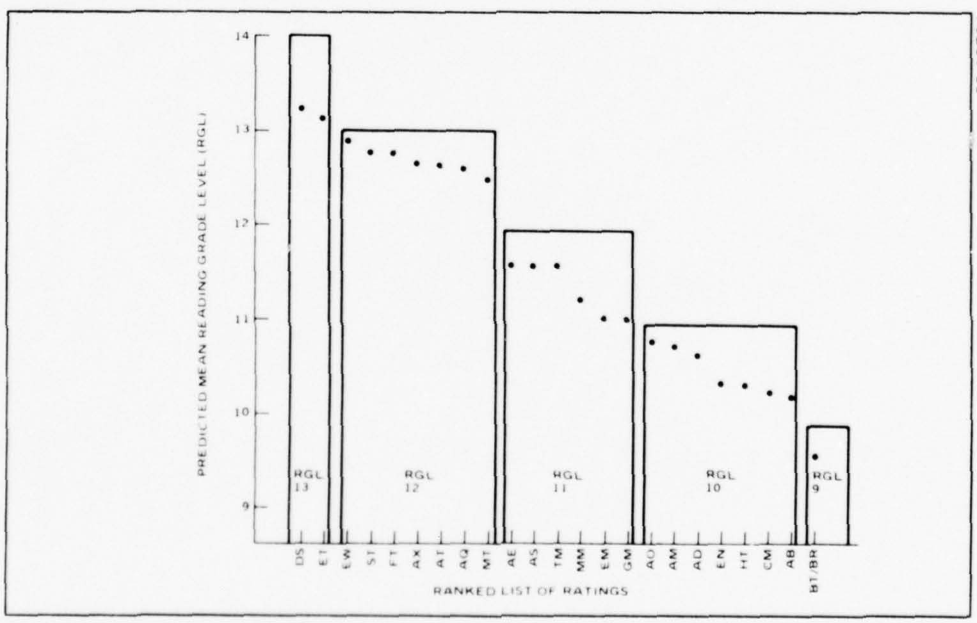
2. READABILITY FINDINGS INVOLVING TM USERS (Continued)

In an unpublished study at NPRDC, Duffy (undated) performed regression analysis of GCT scores and reading grade level of 7,135 recruits. It was found that GCT and RGL correlated r = 0.72. The formula for the regression of reading grade level on GCT score is shown in Figure 2-10, along with a graph of the regression line. Figure 2-10 may be used to predict reading grade level if GCT score is known. For example, if an individual receives a GCT score of 50, it is predicted that his reading grade level will be 10. The average reading level of each of the 23 ratings, as predicted by regression on the general classification test score, is shown in Figure 2-11. Note that the DS and ET ratings are predicted to read at the 13th level. Note that the ratings are predicted to read less than the 9th grade reading level, on the average. When these predicted reading grade levels are averaged over all of the 23 ratings, the mean RGL is found to be 11.6. If we subtract 2.7 (two standard errors) from this figure, we arrive at a reading level of 8.9. In other words, on the basis of regression of reading grade level on known GCT scores, 95 percent of the Naval ratings can read at a reading grade level of nine or above.



79236-10

Figure 2-10. The Regression of Reading Grade Level on the General Classification Test Score, Based on Testing of 7,135 Recruits (Adapted from Duffy, Undated). Dotted lines show dispersion of 1 standard error.



79236-11

Figure 2-11. Dots (●) Show Average Reading Grade Level of Each of 23 Ratings as Predicted by Regression on the General Classification Test Score. Bars indicate ratings grouped within similar reading grade levels.

SECTION 3
CONSTRUCTION OF THE MODEL

1. DEVELOPMENT OF TASK ACTIONS FROM EQUIPMENT TYPES

The NOTAP task analysis data may be summarized by a matrix for each rating, showing task actions performed on hardware items at different levels of complexity.

As discussed under Approach, the first step in developing the model is to identify the task actions by level of hardware complexity (e.g., assembly, equipment, system, etc.) rather than by type of hardware (e.g., computer, drone, radar, etc). This analysis of task actions is different for each rating. Only four ratings were selected for model development: MM, ET, AB, and AT. These ratings were selected to offer maximal diversity of task requirements.

The task data from the NOTAP data bank concerning these four ratings were summarized by construction of Task Action and Equipment Level Complexity Matrices, shown in Tables 3-1 through 3-4. These matrices show the various task actions and their relationship to the hardware items categorized by the four levels of complexity: systems, equipment, assembly, and parts (as defined in Table 2-5). These categorizations were done by judgments based on definitions of complexity levels rather than information from NOTAP. Cell entries (dots) in the matrices indicate which task actions are performed on what items of hardware maintained by the MM, ET, AB, and AT ratings, as indicated by the NOTAP printouts. The NOTAP data base is not a mandatory source of task action data for constructing the User-Data Match Model. Any source which supplies the type of task action data represented in the matrices would suffice, in that what is required is a task list which can serve as a topical listing of what the technical documentation presented to the user must cover.

In using the model, of course, the Navy TM engineer in conjunction with the equipment procurement office will identify the task actions via the hardware items and level involved in his particular system procurement. For guidance, the user will use condensations of NOTAP type data as in Tables 3-1 through 3-4 of this report.

TABLE 3-1. ANALYSIS OF TASK ACTIONS FOR MACHINIST'S MATE (MM) BY LE

	Task Level	Task Action										
		Adjust	Calibrate	Clean	Fill	Inspect	Isolate Faults	Lubricate	Overhaul	Bleed	Purge	Re-lag
System Level	After steering system					•	•					
	Air conditioning chill water system (submarine)					•	•					
	Aircraft elevators					•	•					
	Atmospheric exhaust system					•	•					
	Auxiliary air ejector system					•	•					
	Auxiliary exhaust steam system					•	•					
	Auxiliary gland exhaust system					•	•					
	Auxiliary machinery cooling water system					•	•					
	Auxiliary steam system					•	•					
	Bilge and tank stripping system					•	•					
	Bridge steering telemotor system					•	•					
	Catapult drain system					•	•					
	Catapult stream supply system					•	•					
	Distillate transfer system					•	•					
	Distilling plant chemical cleaning system					•	•					
	External diving system (submarine)					•	•					
	Feedwater transfer system					•	•					
	Firemain system					•	•					
	Fresh water cooling system					•	•					
	Fresh water drain system					•	•					
	High pressure (HP) air system					•	•					
	High pressure drain system					•	•					
	Jet blast deflector system					•	•					
	Low pressure (LP) air system					•	•					
	Lube oil purification and transfer system					•	•					
	Lube oil storage tank piping and fill system					•	•					
	Main air ejector system					•	•					
	Main ballast tank blow system (submarine)					•	•					
	Main circulating system					•	•					
	Main condenser system					•	•					
	Main drainage system					•	•					
	Main feed pump recirculating system					•	•					
	Main gland seal system					•	•					
	Main lube oil system					•	•					
	Main oxygen system (submarine)					•	•					
	Main steam system					•	•					
	Main/vital hydraulic system (submarine)					•	•					
	Makeup feed system					•	•					
	Medium pressure (MP) air system					•	•					
	Oxygen/nitrogen charging system					•	•					
	Oxygen/nitrogen flooding system					•	•					
	Pneumatic main feed pump control system					•	•					
	Sanitary drain system (submarine)					•	•					
	Ship's heating system					•	•					
	Ship's service air system (submarine)					•	•					
	Steering/diving hydraulic systems (submarine)					•	•					
	Trim and drain system (submarine)					•	•					
	Unrep transfer (steam) system					•	•					
	Ventilation/revitalization system (submarine)					•	•					
	Waste and oil separator system					•	•					

ABLE 3-1. ANALYSIS OF TASK ACTIONS FOR MACHINIST'S MATE (MM) BY LEVELS OF COMPLEXITY

	Task Action															
sk Level	Adjust	Calibrate	Clean	Fill	Inspect	Isolate Faults	Lubricate	Overhaul	Bleed	Purge	Re-lag	Remove	Repair	Replace	Service	Test
ng system					•	•										•
ning chill water marine)					•	•										•
vators					•	•										•
c exhaust system					•	•										•
r ejector system					•	•										•
xhaust steam					•	•										•
land exhaust					•	•										•
achinery cooling m					•	•										•
team system					•	•										•
nk stripping					•	•										•
ring telemotor					•	•						•		•		•
ain system					•	•										•
eam supply system					•	•										•
ansfer system					•	•										•
lant chemical stem					•	•										•
ving system					•	•										•
transfer system					•	•										•
ystem					•	•										•
r cooling system					•	•										•
r drain system					•	•										•
re (HP) air					•	•										•
re drain system					•	•										•
flector system					•	•										•
re (LP) air					•	•										•
rification and stem					•	•										•
rage tank piping tem					•	•										•
ector system					•	•										•
t tank blow bmarine)					•	•										•
lating system					•	•										•
nser system					•	•										•
ge system					•	•										•
ump recirculating					•	•										•
seal system					•	•						•		•		•
il system					•	•										•
n system)					•	•										•
system					•	•										•
hydraulic bmarine)					•	•										•
d system					•	•										•
essure (MP) air					•	•										•
rogen charging					•	•										•
rogen flooding					•	•										•
main feed pump tem					•	•										•
ain system)					•	•										•
ng system					•	•										•
ice air system)					•	•										•
ving hydraulic ubmarine)					•	•										•
rain system)					•	•										•
sfer (steam)					•	•										•
/revitalization bmarine)					•	•										•
il separator					•	•										•

 2

1. DEVELOPMENT OF TASK ACTIONS BY LEVELS AND RATING

TABLE 3-1. ANALYSIS OF TASK ACTIONS FOR MACHINIST'S MATE (MM) BY LEVELS OF CO

	Task Level	Task Action											
		Adjust	Calibrate	Clean	Fill	Inspect	Isolate Faults	Lubricate	Overhaul	Bleed	Purge	Re-lag	Remove
Equipment Level	Air compressors					•	•	•	•	•			
	Air conditioning units					•	•	•	•	•	•		•
	Anchor windlass					•	•	•	•				•
	Auxiliary condenser					•	•						•
	Cranes					•	•	•	•				
	De-aerating feed					•	•						•
	Distilling plants					•	•						•
	Emergency diesel engines					•	•	•	•				•
	Escalators					•	•	•					•
	Evaporators					•	•		•				
	Fork lifts/pallet trucks					•	•	•	•				
	Galley equipment (steam kettles/steam line/dish washer/coffee urn)					•	•						•
	Hot water heaters	•				•	•		•	•			•
	Laundry equipment (washers/dryers/pressers/dry cleaning plant)					•	•	•					•
	Liquid oxygen carts				•	•	•	•					
	LOX generating plant					•	•						•
	Lube oil purifiers					•	•		•				•
	Main engine steam turbine					•	•	•					•
	Main thrust block					•	•	•					•
	Oxygen generators					•	•			•			•
	Oxygen/nitrogen carts				•	•	•	•					
	Package conveyors	•				•	•	•					•
	Refrigerators	•				•	•		•	•	•		•
	Scullery equipment (incinerators, garbage grinders, compactors)					•	•		•				•
	Ship's service turbogenerator					•	•		•				•
	Ship's stores equipment (soda fountains, ice cream machines)					•	•			•			•
	Ship's whistle					•	•						•
	Small craft diesel engines					•	•	•	•				•
	Special frequency turbogenerator					•	•						•
	Winches					•	•	•	•				•
Assembly Level	Alarm panels						•						•
	Automatic stanchions						•						•
	Deck edge side door	•					•						•
	Fire pumps						•						•
	Hangar bay div doors/fire curtains						•	•					•
	Main reduction gear and gurning (jacking) gear						•						•
	Steam lines						•					•	
	Steam reducing station						•						•
	Stores/weapons elevator						•	•					•
	Water coolers (scuttlebutts)						•						•
Part Level	Bulkhead stuffing gland			•				•					•
	Elevator locks			•				•					•
	Filters												•
	Flexible couplings			•				•					•
	Main shaft bearings			•				•					
	Pumps							•	•				
	Roller curtains			•									•
	Strainers												•
	Valves	•							•				
	Gauges		•										

/

1. DEVELOPMENT OF TASK ACTIONS BY LEVELS AND RATINGS (Continued)

ANALYSIS OF TASK ACTIONS FOR MACHINIST'S MATE (MM) BY LEVELS OF COMPLEXITY (Continued)

	Task Action															
vel	Adjust	Calibrate	Clean	Fill	Inspect	Isolate Faults	Lubricate	Overhaul	Bleed	Purge	Re-lag	Remove	Repair	Replace	Service	Test
					•	•	•	•	•							•
nits					•	•	•	•	•	•		•		•	•	•
					•	•	•	•				•	•	•		•
er					•	•						•		•		•
					•	•	•	•						•		•
					•	•						•		•		•
					•	•						•		•		•
engines					•	•	•	•				•		•		•
					•	•	•					•		•		•
					•	•		•						•		•
rucks					•	•	•	•						•		•
(steam e/dish n)					•	•						•		•		•
	•				•	•		•	•			•		•		•
nt pressers/ t)					•	•	•					•		•		•
ts				•	•	•	•									
lant					•	•						•		•		•
s					•	•		•				•		•		•
n turbine					•	•	•					•		•		•
					•	•	•					•		•		•
s					•	•			•			•		•		•
carts				•	•	•	•							•		•
rs	•				•	•	•					•		•		•
	•				•	•		•	•	•		•		•	•	•
nt rbage ctors)					•	•		•				•		•		•
					•	•		•				•		•		•
ipment (soda eam					•	•			•			•		•		•
					•	•						•		•		•
engines					•	•	•	•				•		•		•
					•	•						•		•		•
					•	•	•	•				•		•		•
						•						•		•		•
ions						•						•		•		•
oor	•					•						•		•		•
						•						•		•		•
oors/						•	•					•		•		•
ear ing)						•						•		•		•
						•					•					
tation						•						•		•		
elevator						•	•					•		•		•
						•						•		•		•
gland			•				•					•		•		•
			•				•					•		•		•
												•		•		
s			•				•					•	•	•		•
gs			•				•									
							•	•					•			•
			•									•		•		•
												•	•	•		
	•							•					•			•
		•														

2

TABLE 3-2. ANALYSIS OF TASK ACTIONS FOR ELECTRONIC

	Task Level	Tas					
		Adjust	Calibrate	Clean	Isolate Faults	Lubricate	Meas
System Level	Air search radar system				●		
	Distribution main frame				●		
	ECM/ESM system major component				●		
	ECM/ESM system subsystem				●		
	GCA/CCA radar systems - components				●		
	GCA/CCA radar systems - subsystems				●		
	Logic families				●		
	LORAN systems				●		
	Major subsystem in combat system configuration				●		
	Radar/signal distribution system (components, video amps, tripper amps, switchboards)				●		
	Ships audio entertainment system				●		
	SINS	●			●		
	Surface search radar system				●		
	System checks with diagnostic program				●		
	TACAN antenna system facsimile (FAX) to subsystems (recorders, modulators, converters)				●		
	Teletypewriter comparator, converter group (URA B/URA 17)				●		
	TV studio distribution systems				●		
	Weather radar - individual components				●		
	Weather radar - major components				●		
	Weather satellite receiver/recorder system				●		
Equipment Level	Anemometers	●	●		●	●	
	Communications receivers	●			●		
	Components of communications remote (transmitters, controllers, audio amplifiers, etc)				●		
	Computer buffer equipment	●			●		
	Digital comparators				●		
	Fathometer	●	●		●		
	Klystrons				●		
	Mobile transceivers				●		
	Omega receiving set				●		
	Portable transceivers	●			●		
	Radar indicators				●		
	Receiver				●		
	RF power output	●			●		●
	Tape recorders			●	●	●	
	VHF/UHF communications equipment				●		
	Video tape recorders - subassembly	●		●	●	●	
	VLF/LF/HF receivers				●		
	Wave guides				●		

S OF TASK ACTIONS FOR ELECTRONIC'S TECHNICIAN (ET) BY LEVELS OF COMPLEXITY

	Task Action									
te	Clean	Isolate Faults	Lubricate	Measure	Modify	Remove	Replace	Set (Codes)	Test	Tune (Klystrons)
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•								
		•	•						•	
		•							•	
		•			•	•	•		•	
		•			•				•	
		•							•	
		•							•	
		•								•
		•				•	•		•	
		•						•	•	
		•							•	
		•						•	•	
		•							•	
		•		•					•	
	•	•	•						•	
		•			•				•	
	•	•	•			•	•		•	
		•							•	
		•				•	•		•	

1. DEVELOPMENT OF

TABLE 3-2. ANALYSIS OF TASK ACTIONS FOR ELECTRONIC'S TECHN

		T					
	Task Level	Adjust	Calibrate	Clean	Isolate Faults	Lubricate	Mea
Assembly Level	Cables/cable harness				●		
	Computer arithmetic section				●		
	Computer control section				●		
	Computer input/output section				●		
	Computer machine control signal units				●		
	Computer memory section				●		
	Computer typical data terminal sets				●		
	Computer typical magnetic tape units				●		
	Computer typical printer				●		
	Computer typical punched card units				●		
	Computer typical punched tape units				●		
	DC patch boards				●		
	Digital adders/subtractors				●		
	Digital counters/registers				●		
	Digital decoders				●		
	Digital matrices				●		
	Fluorescent lamp fixtures				●		
	Gear trains				●	●	
	Headsets/handsets			●	●		
	Low voltage power supply	●			●		●
	Major component (chassis, PC board circuit)				●		
	Mechanical linkages	●			●	●	
	Negative logic devices				●		
	Oscillators	●	●		●		●
	Positive logic devices				●		
Part Level	AFC circuits						
	Batteries			●			
	Circuits						
	Components on printed circuit boards						●
	CRT						
	Digital and/or NAND/NOR gates						
	Digital logic flip-flop circuits						
	ECM/ESM system failed circuit part						
	Electrical/Electronic components						●
	GCA/CCA radar systems - failed circuit part						
	Individual components (switches, resistors, capacitors)						●
	Micro switches			●			
	Motors/generators - components					●	
	Relays			●			
	Video tape recorders - components			●		●	
	Video tape recorders - failed circuit part						
	Wave guide sections						

/

1. DEVELOPMENT OF TASK ACTIONS BY LEVELS AND RATINGS (Continued)

SK ACTIONS FOR ELECTRONIC'S TECHNICIAN (ET) BY LEVELS OF COMPLEXITY (Continued)

Task Action										
ibrate	Clean	Isolate Faults	Lubricate	Measure	Modify	Remove	Replace	Set (Codes)	Test	Tune (Klystrons)
		●			●	●	●			
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●		●	
		●			●	●	●		●	
		●				●	●		●	
		●				●	●		●	
		●				●	●	●	●	
		●				●	●		●	
		●				●	●		●	
		●	●			●	●		●	
	●	●				●	●		●	
		●		●		●	●		●	
		●				●	●		●	
		●	●			●	●		●	
		●				●	●		●	
●		●		●		●	●		●	
		●				●	●		●	
						●	●		●	
	●					●	●		●	
					●	●	●		●	
				●		●	●		●	
						●	●		●	
						●	●		●	
						●	●		●	
						●	●		●	
				●		●	●		●	
						●	●		●	
				●		●	●		●	
	●					●	●		●	
			●			●	●		●	
	●					●	●		●	
	●		●			●	●		●	
						●	●		●	
						●	●		●	

TABLE 3-3. ANALYSIS OF TASK ACTIONS FOR AVIATION BOATSWAIN'S M

	Task Level	Adjust	Bleed	Calibrate	Clean	Isolate Faults	Inspect	Install	Lubricate	Measure	Rebu
		Task Action									
System Level	Aircraft oxygen systems					•	•				
System Level	Automatic lubrication system					•	•				
System Level	Bridle arrestor system					•	•				
System Level	"CROV" drive system					•	•				
System Level	Flight deck elevators					•	•				
System Level	Fuel systems		•			•	•				
System Level	Hydraulic/pneumatic system		•			•	•	•			•
System Level	Mirror landing system					•	•				
System Level	Manually operated visual landing aid system (MOVLAS)					•	•				
System Level	Piping (fuel, hydraulic, water)		•			•	•				•
Equipment Level	"AG" dynamometer			•		•				•	
Equipment Level	Aircraft handling equipment (towbars, chocks, etc)				•	•	•		•		
Equipment Level	Fire-fighting equipment				•	•	•		•		
Equipment Level	Ground support equipment				•	•	•		•		
Equipment Level	Trail bars (nose to aircraft)				•	•	•		•		
Equipment Level	Vehicles				•	•	•		•		
Assembly Level	"AG" engines	•			•	•	•		•		
Assembly Level	Barricades					•		•	•		
Assembly Level	Bridle arrestor brake assemblies	•			•	•	•			•	•
Assembly Level	Bridle arrestor cam assembly	•			•	•	•		•		•
Assembly Level	Bridle tensioner	•			•	•	•		•		
Assembly Level	C-11/C-7 console	•			•	•	•				
Assembly Level	Cable anchor damper	•			•	•	•		•		
Assembly Level	Catapult hydraulic accumulator		•			•	•				
Assembly Level	Catapult power piston					•	•				
Assembly Level	Catapult power piston assembly					•	•				
Assembly Level	Catapult shuttle assembly				•	•	•				
Assembly Level	Clutch assembly	•				•	•				
Assembly Level	Constant runout valve (CROV)	•				•	•	•			
Assembly Level	Cross-deck pendants	•			•	•	•				•
Assembly Level	Drag chutes					•		•			
Assembly Level	Equipment/gear/switches	•			•	•	•	•			•
Assembly Level	Fuel transfer lines		•		•	•	•				
Assembly Level	Hydraulic pumps		•			•	•	•			•
Assembly Level	Launch/exhaust valve operating cylinder	•				•	•				
Assembly Level	Lifting slings and cables					•	•	•			
Assembly Level	Main engine retraction cylinder					•	•				
Assembly Level	Pneumatic systems	•	•		•	•	•		•		•
Assembly Level	Pressure regulators	•			•	•	•	•			
Assembly Level	Retract buffer	•				•	•	•			
Assembly Level	Sealing stripe tensioner	•				•	•				
Assembly Level	Shore-based "AG" rewind engines	•			•	•	•	•	•		
Assembly Level	Sound powered phones					•					
Assembly Level	Vehicle transmissions, engines, rear ends, etc						•		•		
Assembly Level	Water brake	•			•		•	•			

TASK ACTIONS FOR AVIATION BOATSWAIN'S MATE (AB) BY LEVELS OF COMPLEXITY

Task Action														
lean	Isolate Faults	Inspect	Install	Lubricate	Measure	Rebuild	Recharge	Remove	Repair	Replace	Rig	Service	Test	Torque
	●	●										●		
	●	●												
	●	●										●		
	●	●										●		
	●	●										●		
	●	●										●		
	●	●	●			●	●					●		
	●	●										●		
	●	●						●			●	●		
	●	●				●								
	●				●						●			
●	●	●		●						●		●		
●	●	●		●								●		
●	●	●		●						●		●		
●	●	●		●						●		●		
●	●	●		●						●		●		
●	●	●		●				●		●		●		
	●		●	●				●	●	●	●	●		
●	●	●			●	●				●		●		
●	●	●		●		●		●		●		●		
●	●	●		●				●		●		●		
●	●	●							●	●		●	●	
●	●	●		●						●		●		
	●	●								●		●		
	●	●								●		●		
	●	●							●	●		●		
●	●	●						●		●		●		
	●	●						●		●				
	●	●	●					●		●	●	●		
●	●	●				●		●		●	●	●	●	
	●		●					●						
●	●	●	●			●		●		●		●		
●	●	●						●		●				
	●	●	●			●		●		●		●		
	●	●						●		●			●	
	●	●	●						●	●			●	
	●	●								●		●		
●	●	●		●		●	●	●	●	●		●	●	
●	●	●	●					●		●		●	●	
	●	●	●					●	●	●		●		
	●	●						●	●	●			●	
●	●	●	●	●				●	●	●		●	●	
	●							●					●	
		●		●				●		●		●		
●		●	●					●		●		●		

2

TABLE 3-3. ANALYSIS OF TASK ACTIONS FOR AVIATION BOATSWAIN'S

	Task Level	Task Acti								
		Adjust	Bleed	Calibrate	Clean	Isolate Faults	Inspect	Install	Lubricate	Me
Part Level	"AG" torque release coupling				●		●			
	Aircraft launching hardware				●		●	●	●	
	Arresting gear cable sockets				●		●			
	Bearings				●		●			
	Bridle arrestor track						●			
	Bridle arrestor track bolts						●	●		
	Broken bolts/studs						●			
	Cable guides				●		●			
	Catapult shuttle assembly rollers				●		●			
	Catapult slot seals						●			
	"CROV" cam						●			
	E-15/E-27 "AG" cam						●			
	Fair lead sheaves				●		●			
	Fire bottles						●			
	Fittings (flanges, valves, etc)				●		●			
	Flight deck safety nets						●			
	Gauges			●			●			
	Hose couplings						●			
	Hydraulic filters						●	●		
	Motor and pump flexible couplings	●			●		●	●	●	
	Nitrogen bottles						●			
	"O" rings						●	●		
	Packing glands						●	●		
	Piston guide				●		●			
	Purchase cable						●	●		
	Retraction engine sheaves				●		●	●		
	Sheave lip						●	●		
	Sheave spacer						●	●		
	Sight glass gauge						●	●		
	Tubing/hoses						●	●		
	Valves						●	●		
	Valves/cylinders packing						●	●		
	Water strainers				●		●	●		
	Wire rope				●		●	●		

1. DEVELOPMENT OF TASK ACTIONS BY LEVELS AND RATINGS (Continued)

FOR AVIATION BOATSWAIN'S MATE (AB) BY LEVELS OF COMPLEXITY (Continued)

Task Action

Inspect	Install	Lubricate	Measure	Rebuild	Recharge	Remove	Repair	Replace	Rig	Service	Test	Torque
●						●						●
●	●	●		●		●	●	●		●		
●						●		●				
●						●						
●								●				
●	●					●		●				
●						●		●				
●								●				
●						●		●				
●						●		●				
●						●		●				●
●						●		●				
●			●			●		●				
●						●		●				
●						●		●				
●						●	●	●	●			
●						●					●	
●						●		●				●
●	●					●						
●	●	●				●		●				
●					●			●		●		
●	●					●		●				
●	●					●		●				
●			●			●						
●	●					●	●	●				
●	●		●			●		●				
●	●		●					●				
●	●		●					●				
●	●					●						
●	●					●	●	●				
●	●		●	●		●	●	●				
●	●					●		●				
●	●					●		●				
●	●					●		●				

2

TABLE 3-4. ANALYSIS OF TASK ACTIONS FOR AVIATION ELECTRONICS TECHNICIA

	Task Level	Task Action							
		Adjust	Calibrate	Degauss	Dispose of	Inspect	Install	Measure	Remove
System Level	Aircraft systems	•				•			
	ASW systems					•			
	Communication systems					•			
	Computer systems					•			
	Drone ground control systems					•			
	Drones/drone systems					•	•		
	Dual radar antenna system					•			
	ECM systems					•			
	Electrical systems					•			
	Electronic systems					•			
	Equipment cooling systems					•			
	Infrared systems					•			
	Intercom/PA systems					•			
	Navigation systems					•			
	Optical systems					•			
	Radar systems					•			
Equipment Level	Electric/electronic test equipment					•	•		•
	Electronic equipment	•		•		•	•		•
	Klystrons					•	•		•
	Test sets		•			•			•
	Torque wrenches		•			•			
	Vacuum equipment					•	•		•
Assembly Level	Aircraft engines								
	Automatic frequency control								•
	Coaxial cables					•	•		•
	Countermeasures cans					•			•
	Electric motors								
	Electrical wiring					•	•		•
	Gear trains					•			
	Guns								
	High voltage power supplies					•	•		•
	Indicators, transmitters, gauges						•		•
	Intervalometer timers	•							•
	Low voltage power supplies	•					•		•
	Mechanical linkages	•				•	•		•
	Microminiature circuits								•
	Servo amplifiers								•
	Synchros/resolvers	•							•
Part Level	Balance weights					•	•	•	•
	Cathode ray tubes				•	•			•
	Common hardware					•	•		•
	Electronic components								•
	Equipment/gear/switches								
	Knobs, lights, fuses					•	•		•
	Mechanical components	•				•	•		•
	Micro switches	•				•	•		•
	"O" rings, gaskets, seals, etc								•
	Oscillators	•				•	•		•
	Pressure gauge	•							•
	Radioactive material				•				
	Transistors								•
	Waveguide sections								

SK ACTIONS FOR AVIATION ELECTRONICS TECHNICIAN (AT) BY LEVELS OF COMPLEXITY

Task Action												
rate	Degauss	Dispose of	Inspect	Install	Measure	Remove	Repair	Replace	Service	Test	Isolate Faults	Tune
			•						•		•	
			•								•	
			•								•	
			•								•	
			•				•				•	
			•	•							•	
			•								•	
			•								•	
			•								•	
			•								•	
			•								•	
			•								•	
			•								•	
			•								•	
			•								•	
			•								•	
			•	•		•	•			•	•	
	•		•	•		•				•	•	
			•	•		•				•	•	•
•			•			•				•	•	
•			•								•	
			•	•		•					•	
									•		•	
						•				•	•	
			•	•		•	•			•	•	
			•			•		•			•	
								•			•	
			•	•		•	•	•		•	•	
			•								•	
			•	•		•		•		•	•	
				•		•		•		•	•	
						•		•		•	•	
				•		•		•		•	•	
			•	•		•		•		•	•	
						•		•			•	
						•		•		•	•	
						•		•		•	•	
			•	•	•	•		•				
		•	•			•		•		•		
			•	•		•		•				
						•		•				
										•		
			•	•		•		•		•		
			•	•		•		•		•		
			•	•		•		•		•		
						•		•		•		
			•	•		•		•				
						•	•	•		•		
		•										
						•		•		•		
							•				•	

2. CLASSIFICATION OF TASK ACTIONS BY HARDWARE COMPLEXITY LEVEL

Commonalities in the hardware maintained by each rating group permit the task actions to be classified by level of hardware complexity, thus simplifying the specification of presentation components.

A critical review of the matrices shown in Tables 3-1 through 3-4 reveal a clustering of similar items within complexity levels for each rating. For example, the hardware maintained by the Machinist Mate at the systems level is all hydraulic or pneumatic. Thus, although the purposes of the hardware vary, the hardware designs would share many commonalities. This type of similarity permits further data reduction of the NOTAP based summary data. Thus, the next step in the task analysis was to condense the data displayed in Tables 3-1 through 3-4 by removing reference to specific hardware items, and showing only the relationship between task actions and complexity levels.

The results of this condensation are presented as matrices in Tables 3-5 through 3-8. An entry in a cell formed by the intersection of two axes of one of these matrices indicates that the technician performs a specific task action (e.g., "Test") on at least one item of hardware at the noted complexity level (e.g., "Assemblies"). Note that each of the matrices contain the same first six task actions, although the levels of complexity at which these task actions are performed often differ. The commonality of some of the task action verbs is not intended to imply they mean exactly the same thing to each rating. Fault isolation, for example, may be expected to entail quite different actions for the ET versus the AB. Furthermore, the task action verbs may not mean exactly the same thing at different levels of complexity. Fault isolation of systems is usually very different from fault isolation of parts.

These matrices are not themselves part of the User-Data Match Model. However, their cell entries form a bridge to constructing the final set of matrices. Since they specify task actions at complexity levels for each rating, they become one axis of the matrix (described in the following topics) for selecting the most suitable presentation components to aid the rating in the performance of the listed task actions.

TABLE 3-5. NUMBER OF TASK ACTIONS AT EACH LEVEL OF COMPLEXITY PERFORMED BY MACHINIST'S MATE (MM)

	Task Action											
	Common to Ratings MM, AB, AT, and ET						Isolated for ET*					
Complexity Level	Adjust	Calibrate	Isolate Faults	Remove	Replace	Test	Clean	Lubricate	Modify	Measure	Set (Codes)	Tune
Systems	•		•									
Equipment	•	•	•	•	•	•	•	•	•	•	•	•
Assemblies	•	•	•	•	•	•	•	•	•	•	•	
Parts				•	•	•	•	•	•	•		

*Some task actions in this group may also be done by other ratings.

TABLE 3-6. NUMBER OF TASK ACTIONS AT EACH LEVEL OF COMPLEXITY PERFORMED BY ELECTRONICS TECHNICIAN (ET)

	Task Action															
	Common to Ratings MM, AB, AT, and ET							Isolated for MM*								
Complexity Level	Adjust	Calibrate	Isolate Faults	Remove	Replace	Test	Bleed	Clean	Fill	Inspect	Lubricate	Overhaul	Purge	Re-Lag	Repair	Service
Systems			•	•	•	•				•						
Equipments	•		•	•	•	•	•		•	•	•	•	•		•	•
Assemblies	•		•	•	•	•					•			•		
Parts	•	•		•	•	•		•			•	•			•	

*Some task actions in this group may also be done by other ratings.

2. CLASSIFICATION OF TASK ACTIONS BY HARDWARE COMPLEXITY LEVEL (Continued)

TABLE 3-7. NUMBER OF TASK ACTIONS AT EACH LEVEL OF COMPLEXITY PERFORMED BY AVIATION BOATSWAIN'S MATE (AB)

	Task Action																	
	Common to Ratings MM, AB, AT, and ET						Isolated for AB*											
Complexity Level	Adjust	Calibrate	Isolate Faults	Remove	Replace	Test	Bleed	Clean	Install	Inspect	Lubricate	Measure	Rebuild	Recharge	Repair	Rig	Service	Torque
Systems			•	•			•		•	•			•	•		•	•	
Equipment	•	•	•		•			•		•	•	•				•	•	
Assemblies	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Parts	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•

*Some task actions in this group may also be done by other ratings.

TABLE 3-8. NUMBER OF TASK ACTIONS AT EACH LEVEL OF COMPLEXITY PERFORMED BY AVIATION ELECTRONICS TECHNICIAN (AT)

	Task Action													
	Common to Ratings MM, AB, AT, and ET						Isolated for AT*							
Complexity Level	Adjust	Calibrate	Isolate Faults	Remove	Replace	Test	Degauss	Dispose of	Inspect	Install	Measure	Repair	Service	Tune
Systems	•		•						•	•		•	•	
Equipment	•	•	•	•		•	•		•	•		•		•
Assemblies	•		•	•	•	•			•	•		•	•	
Parts	•		•	•	•	•		•	•	•	•	•		

*Some task actions in this group may also be done by other ratings.

3. CODING THE MODEL FOR UTILITY AND VALIDITY

A coding scheme is described which enables the matrix entries to be interpreted in terms of their utility and validity.

Entries in the presentation components matrix indicate a recommended selection of component for each task action. Although checked (X) cells could be used to indicate the recommendation, important corollary information would be lost. For example, the user of the matrix would like to know the importance of the chosen presentation component as an aid to understanding the maintenance task, the basis for selecting the component, and what combinations of presentation components are most effective.

Accordingly, a three-part code has been developed with alpha-numeric-subscript components, for example $B3_2$. Each component is described below under the headings of utility of information, source value, and presentation component combination coding.

Utility Scale – The first part of the code is the utility scale. There are three levels of utility, coded as follows:

Code	Rating	Definition
A	Ideal	The presentation component is the best possible way of portraying technical information for conducting maintenance tasks.
B	Good	Though far from ideal, the presentation component is of value to the user performing maintenance tasks.
C	Fair	The presentation component does not show technical information well but is of some assistance to the user.

Information Source Value Scale – The second part of the code provides the information source value. Though the utility scale indicates usefulness of a presentation component, users of the model need to know the "confidence" they can place in the alphabetical levels used in the utility scale. For example, although a certain pairing of presentation component tasks would seem ideal, one wonders what the rationale is for making such a pairing. A simple way of coding source information relating to selection of components, which becomes the second part of the code, is shown below.

Code	Validity Rating	Definition
1	Incontrovertible	Data is available from controlled experimental studies.
2	Strong	Data has been gathered by systematic field surveys.
3	Moderate	Information source is a recognized expert(s) from the user population.
4	Subjective	Analytical judgment based on literature references and/or personal observations.

When both utility and source value scale codes are combined, alphanumeric codes such as A2 (ideal presentation component according to survey data), or B3 (good presentation component based on expert opinion) may be used. The entries in the cells of the matrices are illustrated in Figure 3-1. When the manual writer needs information on the best presentation components for a given maintenance task, he will read across the column by rows. He will note that each task action is keyed across the rows to a number of entries indicating the utility and information source value of various presentation components. More than one cell entry in a row means that each noted presentation component should be used to present technical information for the given task action. For example, in Figure 3-1, the "repair" task action should be aided by three presentation components, (C3) exploded view and (A2) schematic, and (B4) directive text. Presentation components should not be substituted for each other unless the code carries a subscript (see below).

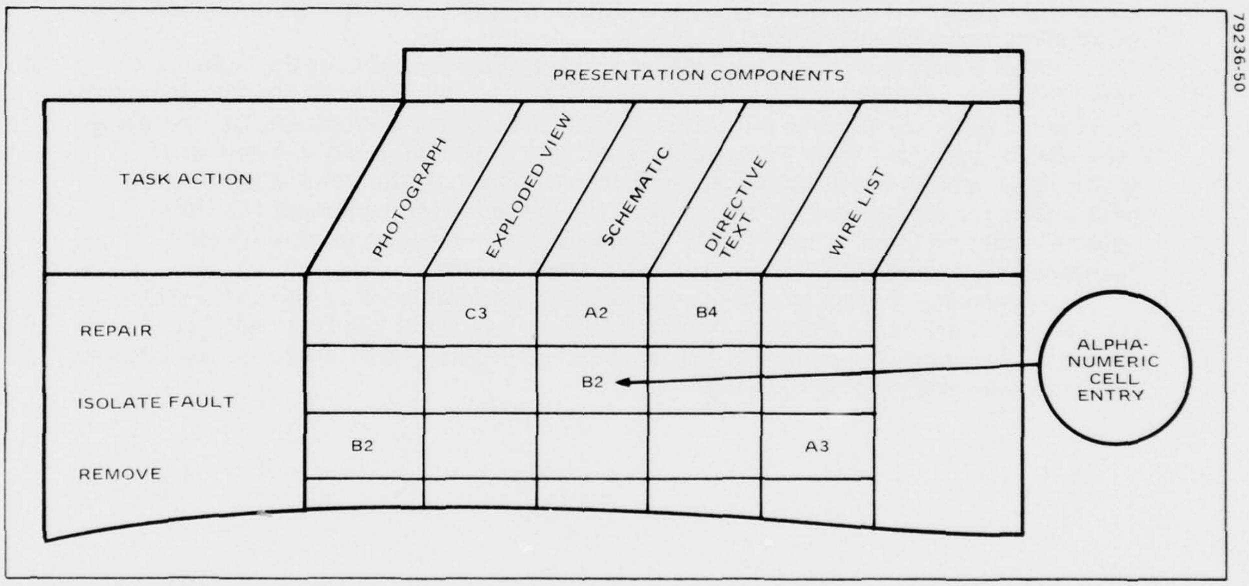


Figure 3-1. Example of a Utility Scale and Information Source Value Scale in a Presentation Component-Maintenance Task Action Matrix

3. CODING THE MODEL FOR UTILITY AND VALIDITY (Continued)

Presentation Component Combination Code – The third part of the code is to denote presentation component combinations.

In some cases, choices will be available between presentation components, such as photographs and airbrushed drawings. Individually they are useful for presenting technical information. Alternatively, they might both be used in combination to enhance the presentation of information. These and/or cases required addition of subscripts (e.g., $A2_1$) to show combinations or alternatives among presentation components. If a subscript appears in a matrix cell, one or more cells in the same row will have it. This means that two or more cells may be used, with one substituting for the other.

Figure 3-2 shows an example of the subscript code. Interpretation of the entries is as follows: for "fault isolation" at the equipment level, (A1) detailed block diagrams and (A2) schematics should both be used in the presentation of technical information. For "removal" at the assembly level the subscript (1) indicates that either (A2) photographs or (A1) sketches or both may be used to present the necessary technical information. For "lubrication" at the part level the subscripts (1) and (2) indicate that choices may be made between (B2) photographs and (B3) sketches, between (B4) exploded view and (B3) cutaway view, and between (B3) cutaway view, and (A2) schematics.

Some cells will have multiple subscripts. For example, in the "lubricate part" row, the cell coded (B3) cutaway view, has two subscripts (2,3). This indicates that such a cell may be used with other cells with the same subscript, i.e., cutaway view and/or exploded view, or cutaway view and/or schematics. If a cell with multiple subscripts is not used (i.e., an alternate is used), the cells which remain with unlike (or no) subscripts require that the presentation component in these columns must be used. Thus, if (B3) "cutaway view" were not used, both (B4) "exploded view" and (A2) "schematic" would be required.

Given the matrix and the coding system (see Tables 3-12 through 3-15) it can be seen on Table 3-9 that the machinist's mate (MM) has little need for servicing diagrams, for example, but would be greatly aided by sketches, air-brushed drawings, and engineering drawings.

TASK ACTIONS	PRESENTATION COMPONENTS						
	PHOTOGRAPH	SKETCH	EXPLODED VIEW	CUTAWAY VIEW	DETAILED BLOCK DIAGRAMS	SCHEMATICS	MATERIALS LIST
EQUIPMENT FAULT ISOLATE					A1	A2	
ASSEMBLY REMOVE	$A2_1$	$A2_1$					
PART LUBRICATE	$B2_1$	$B3_1$	$B4_2$	$B3_{2,3}$		$A2_3$	B3

79236-51

Figure 3-2. Example of Presentation Component Combination Coding in Cells Containing Utility and Source Value Coding

4. THE SELECTION MATRIX FOR PRESENTATION

The presentation selection matrices enable the user to select recommended presentation components for each specific task action requirements performed by a given rating.

The recommendations would be validated by best available procedures for determining the appropriateness of presentation component.

The NOTAP-based task data (task actions by levels of complexity from Tables 3-5 through 3-8) are used to construct one axis of the Presentation Components Selection Matrix (Tables 3-9 through 3-12). For example, Table 3-6 shows that the MM is sometimes called upon to test hardware at the systems level. Thus "systems test" becomes a row in the MM version of the presentation selection matrix (Table 3-9).

The columns of the model matrices represent various presentation components. Presentation components are specific technical information presentation aids, such as photographs or block diagrams. The forty presentation components were subdivided into four categories: pictorial representation, diagrammatic representation, text, and condensed data. Each of the components grouped under those four headings is illustrated in Appendix C of this report. This listing of presentation components is the result of an attempt to assemble a set of basic elements sufficient to construct any presentation format by means of variations and combinations.

The matrices of the User-Data Match Model are arranged into rows of task actions and columns of presentation components. While the column headings remain the same on every matrix of the model, the row titles vary with the task actions required of each rating. Separate matrices are provided for each rating to reflect the appropriate list of task actions and the presentation components best for each task action for that particular rating. Proper consideration of personnel characteristics are thus implicit in the construction of the matrices.

Each entry is coded (e.g., B4) to show relative merits and source authority for a given selection (see previous topic). An entry in a cell of these matrices indicates that the presentation component of that column is recommended for aiding the task activity of that row.

Notice that most of the entries in these matrices have a code of "4", indicating that the recommendation is subjective and based upon an analytical judgement made from liturature references or personel observations. Those entries having a code of "2" in these matrices are founded upon the Hughes Fleet Survey of 1976. To receive a code of "1", controlled experiments would have to be performed demonstrating incontrovertably the value of the given presentation component in aiding the task action.

While the row titles (task actions) vary in each matrix, there are similarities. The matrices for the MM and the ET, for example, both have rows for "isolate faults at the systems level". Yet the entries in this row are different in the two matrices. The differences in the entries are indicative of differences between the ratings: task actions do not always mean the same thing to different ratings, and the appropriate presentation components will also vary with differences in personnel characteristics.

For convenience of the user, the upper left-hand corner of each matrix contains a small block which identifies the rating to which each matrix pertains, plus pertinent data including major work emphasis, average reading grade level, and the average estimate of weeks of Navy school training required for job performance. This material is presented merely to provide cues to the matrix user about the general nature of the rating, and not directly for selection of componetns.

TABLE 3-9. SELECTION GUIDE RELATING TASKS AT FOUR LEVELS OF EQUIPMENT COMPLEXITY TO

MACHINIST MATE (MM)
Major Work Emphasis: Flow Systems
Reading Grade Level: 11.3
Est wks School Requd: 18.4

Task Actions by Levels of Complexity		Pictorial Representation															Dia			
		Portrayal					View		View Type			Locators/ Identifiers			Blocks		Interconne			
		Photograph	Airbrush Photo	Airbrushed Drawing	Sketch	Engineering Drawing	Two-Dimensional	Three-Dimensional	Assembled	Exploded	Cut-Away	Superimposed	Coordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Sign
Systems	Inspect			$B4_1$		$A2_1$									B2					
	Isolate Faults					A2									B2		$B4_1$		B4	
	Remove			$B4_1$		$A2_1$				B4		$B4_2$		$A4_2$			B4			
	Replace			$B4_1$		$A2_1$				B4		$B4_2$		$A4_2$			B4			
	Test					A2			B4					$A4_2$			$B4_1$			
Equipment	Adjust			$B4_1$	$B4_1$				B4			$B4_2$		$A4_2$			$B4_3$			
	Bleed				B4				B4					A4						
	Fill			$B4_1$	$B4_1$				B4		B4	$B4_2$		$A4_2$						
	Inspect					A2			B4					A4			$B4_1$			
	Isolate Faults			$B4_1$	$B4_1$	$A2_1$		B4	B4		B4						$B4_1$			
	Lubricate					A4			B4					A4						
	Overhaul			$B4_1$	$B4_1$	A2				B4				A4			$B4_1$		B4	
	Purge				A2				B4					A4	B2					
	Remove					A2		B4		B4				A4			$B4_1$			
	Repair					A2										B4				
	Replace					A2		B4		B4				A4			$B4_1$			
	Service				A2				B4					A4						
	Test			$B4_1$	$B4_1$				B4			$B4_2$		$A4_2$			$B4_3$			
Assemblies	Adjust				B4			B4	B4	B4				A4						
	Isolate Faults				$B4_1$	$A2_1$			B4			$B4_2$		$A4_2$			$B4_3$			
	Lubricate				B4				B4					A4						
	Re-lag		$B4_1$		$B4_1$					B4		$B4_2$		$A4_2$						
	Remove				$B4_1$	$A2_1$		B4		B4				A4			$B4_2$			
	Replace			$B4_1$	$B4_1$	$A2_1$		B4		B4				A4			$B4_1$			
	Test			$B4_1$	$B4_1$		$B4_2$	$B4_2$	B4					A4			$B4_3$			
Parts	Adjust				B4			B4	B4					A4						
	Calibrate			$B4_1$	$B4_1$		B4		B4			$B4_2$		$A4_2$						
	Lubricate				B4				B4			$B4_1$		$A4_1$						
	Overhaul					A4														
	Remove			$B4_1$	$B4_1$	$A2_1$		B4		B4				A4						
	Repair						B4							A4						
	Replace					A2								A4						
	Test			$B4_1$	$B4_1$			B4						A4						

QUIPMENT COMPLEXITY TO PRESENTATION COMPONENTS OF "HARD COPY" PRESENTATION COMPONENTS

Locators/ Identifiers		Diagrammatic Representation															Text				Condensed Data							
Locators/ Identifiers		Blocks		Interconnections					Hybrid Blocks			Servicing					Mode		Style		Lists				Tables		Matrices	
rdinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Signal Flow	Digital Logic	Blocked Schematics	Blocked Digital Logic	Pictorial Block	Timing	Maintenance Dependency Chart	Decision Trees	Waveforms	Graphs	Directive	Deductive	Continuous	Segmented	Retrieval-Oriented	Glossary/Abbreviations	Materials	Wire	Procedures	Specialized Data	Specialized Data	Retrieval-Oriented Matrix
		B2							B4		B4$_1$						B4			B4								
		B2		B4$_1$		B4			B4$_1$					A4			B4			B4	B4							B4
	A4$_2$			B4													B4			B4						B4		
	A4$_2$			B4													B4			B4			B4			B4		
	A4$_2$			B4$_1$					B4$_1$							B4	B4			B4						B4		
	A4$_2$			B4$_3$					B4$_3$								B4			B4			B4			B4		
	A4																B4			B4								
	A4$_2$																B4			B4						B4		
	A4			B4$_1$					B4$_1$								B4			B4						B4		
				B4$_1$					B4$_1$					B4			B4			B4						B4		B4
	A4																B4			B4			B4					
	A4			B4$_1$		B4			B4$_1$								B4			B4			B4			B4		B4
	A4	B2															B4			B4								
	A4			B4$_1$					B4$_1$								B4			B4						B4		
			B4														B4			B4			B4	B4	B4	B4		
	A4			B4$_1$					B4$_1$								B4			B4			B4			B4		
	A4																B4			B4						B4		
	A4$_2$			B4$_3$					B4$_3$			B4				B4	B4			B4						B4		B4
	A4																B4			B4						B4		
	A4$_2$			B4$_3$					B4$_3$				B4				B4			B4								B4
	A4																B4			B4			B4			B4		
	A4$_2$																B4			B4			B4			B4		
	A4			B4$_2$					B4$_2$								B4			B4					B4			
	A4			B4$_1$					B4$_1$								B4			B4			B4		B4	B4		
	A4			B4$_3$					B4$_3$							B4	B4			B4						B4		
	A4																B4			B4						B4		
	A4$_2$																B4			B4						B4		
	A4$_1$																B4			B4			B4					
																	B4			B4			B4				B4	B4
	A4																B4			B4								
	A4																B4			B4	B4					B4		
	A4																B4			B4			B4			B4		
	A4																B4			B4						B4		

TABLE 3-10. SELECTION GUIDE RELATING TASKS AT FC
PRESENTATION COMPONENTS OF "HARD CO

ELECTRONICS TECHNICIAN (ET)

Major Work
Emphasis: Surface Electrn
Reading Grade Level: 13.1
Est Wks School Reqd: 41.2

	Task Actions by Levels of Complexity	Pictorial Representation													Dia					
		Portrayal					View		View Type			Locators/ Identifiers			Blocks		Interconne			
		Photograph	Airbrush Photo	Airbrushed Drawing	Sketch	Engineering Drawing	Two-Dimensional	Three-Dimensional	Assembled	Exploded	Cut-Away	Superimposed	Coordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Signal
Sys-tem	Adjust														B4					
	Isolate Faults														B4		$A2_1$			
Equipment	Adjust																$A2_1$			
	Calibrate																			
	Clean				B4				B4					B4						
	Isolate Faults														B2		$A2_1$			
	Lubricate				B4				B4			$B4_1$		$B4_1$						
	Measure																$A2_1$			
	Modify					B4				B4				B4	A2		$A2_1$			
	Remove				B4					B4		$B4_2$		$B4_2$		B2	$A2_1$			
	Replace				B4					B4				B4		B2	$A2_1$			
	Set (Codes)																			
	Test														B4		$A2_1$		B4	A4
	Tune																$A2_1$			
Assemblies	Adjust																A2			
	Calibrate																			
	Clean				B4				B4					B4						
	Isolate Faults															B2	$A2_1$			B4
	Lubricate				B4				B4					B4						
	Measure																A2			
	Modify									B4				B4			$A2_1$			B4
	Remove				B4					B4				B4			$A2_1$			
Part	Replace				B4					B4				B4			$A2_1$			B4
	Set (Codes)																			
	Test														A2		$A2_1$			
	Clean				B4				B4					B4						
	Isolate Faults																$A2_1$			
	Lubricate				B4									B4						
	Measure																			
	Modify				B4							$B4_1$		$B4_1$						
	Remove				B4				B4			$B4_1$		$B4_1$						
	Replace				B4				B4			$B4_1$		$B4_1$						
	Test																A2			

GUIDE RELATING TASKS AT FOUR LEVELS OF EQUIPMENT COMPLEXITY TO
N COMPONENTS OF "HARD COPY" PRESENTATION COMPONENTS

tion			Diagrammatic Representation															Text				Condensed Data							
ype	Locators/ Identifiers		Blocks		Interconnections					Hybrid Blocks			Servicing					Mode		Style		Lists				Tables		Matrices	
perimposed	Coordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Signal Flow	Digital Logic	Blocked Schematics	Blocked Digital Logic	Pictorial Block	Timing	Maintenance Dependency Chart	Decision Trees	Waveforms	Graphs	Directive	Deductive	Continuous	Segmented	Retrieval-Oriented	Glossary/Abbreviations	Materials	Wire	Procedures	Specialized Data	Specialized Data	Retrieval-Oriented Matrix
			B4							$A2_1$		A2						B4									B4		
			B4		$A2_1$					$A2_1$								B4	B4				B4						B4
					$A2_1$					$A2_1$																			
													B4			B4	B4	B4			B4								
		B4								B4								A4			B4			A2					
			B2		$A2_1$					$A2_1$				$B4_2$	$B4_2$							B4				B2	B4		
1		$B4_1$																A4			A4			A2					
					$A2_1$					$A2_1$			A4			A4	A4	A4									B4		
		B4	A2		$A2_1$					$A2_1$								A4			A4			B2			B4		
2		$B4_2$		B2	$A2_1$					$A2_1$								A4			A4								
		B4		B2	$A2_1$					$A2_1$								A4			A4						B4		
																		A4			A4						B4		
			B4		$A2_1$		B4	A4		$A2_1$						B4	B4												
					$A2_1$					$A2_1$								A4			B4						B4		
					A2													B4			B4						B4		
													B4			B4	B4	A4			A4						B4		
		B4																B4			B4			B2					
				B2	$A2_1$			B4		$A2_1$				$B4_1$	$B4_1$				B4	B4							B4		
		B4																B4			B4			B2					
					A2					$A2_1$			B4		B	B4	B4										B4		
		B4			$A2_1$			B4		$A2_1$								B4			B4			B2			B4		
		B4			$A2_1$					$A2_1$								B4			B4								
		B4			$A2_1$			B4		$A2_1$								B4			B4								
																		B4			B4								
			A2		$A2_1$					$A2_1$			B4			B4	B4		B4	B4					A4				
		B4																B4			B4			B2					
					$A2_1$					$A2_1$		B2							B4	B4							B4		
		B4																B4			B4			B2					
																A4	A4	B4			B4						B4		
		$B4_1$																B4			B4			B2			B4		
		$B4_1$																B4			B4								
		$B4_1$																B4			B4			B2			B4		
					A2											A4		B4			B4						B4		

 2

TABLE 3-11. SELECTION GUIDE RELATING TASKS AT FOUR LEVELS OF EQ[illegible]
PRESENTATION COMPONENTS OF "HARD COPY" PRESENTATION[illegible]

AVIATION BOATSWAIN'S MATE (AB)
Major Work
Emphasis: Mech/Hydraulic
Reading Grade Level: 10.3
Est Wks School Reqd: 6.4

	Task Actions by Levels of Complexity	Pictorial Representation														Diagrammatic Representation													
		Portrayal					View		View Type			Locators/ Identifiers			Blocks		Interconnections					Hybrid Blocks			Servi[illegible]				
		Photograph	Airbrush Photo	Airbrushed Drawing	Sketch	Engineering Drawing	Two-Dimensional	Three-Dimensional	Assembled	Exploded	Cut-Away	Superimposed	Coordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Signal Flow	Digital Logic	Blocked Schematics	Blocked Digital Logic	Pictorial Block	Timing	Maintenance Dependency Chart	Decision Trees	Waveforms	[illegible]
System	Bleed			$B4_1$	$A4_1$			B4	A4					A4			$A4_2$							$B4_2$					
System	Isolate Faults				B4						B4			A4	$A4_1$		$B4_2$					$A4_2$		$B4_1$			$B4_3$		
System	Inspect			B4	B4				B4					A4	$A4_2$									$A4_2$					
System	Install				B4	A2		B4	$A4_1$	$B4_1$	$A4_1$			A4	$A4_2$				A4					$A4_2$					
System	Rebuild				B4	A2		B4		A4	B4			A4				B4											
System	Recharge				B4			B4	B4													B4							
System	Remove			B4	B4			B4		$A4_2$	$A4_2$			A4	B4		A4		A4					B4					
System	Rig			$B4_1$	$A4_1$	A2		B4	A4					A4					B4					B4					
System	Service			$B4_1$	$B4_1$			B4	A4					A4		B4	$B4_2$					$B4_2$		B4					
Equipment	Calibrate				B4			B4	B4					A4			$B2_1$					$B2_1$		B4				B4	B4
Equipment	Clean							B4		B4				A4															
Equipment	Inspect			$B4_1$	$B4_1$			B4	B4					A4										B4					
Equipment	Install				B4	A2		B4			B4			A4			B4		B4					B4					
Equipment	Lubricate				B4			B4	B4					A4			B4												
Equipment	Measure				B4	A2		B4		B4				A4			B4											B4	B4
Equipment	Replace			$B4_1$	$B4_1$	A2		B4		B4				A4			B4		B4					B4					
Equipment	Rig				B4	A2		B4	B4					A4					B4					B4					
Equipment	Service				B4				B4					A4			B4							B4					B4
Assemblies	Adjust				B4				B4					A4			B2												B4
Assemblies	Bleed				B4			B4	B4					A4			B2							B4					
Assemblies	Clean				B4			B4		B4				A4															
Assemblies	Isolate Faults			$B4_1$	$B4_1$			B4		B4				A4			$B2_3$	B4				$B2_3$					B4		B4
Assemblies	Inspect				A2			B4	B4	B4				A4															
Assemblies	Install				B4	A2		B4		B4				A4			B2		B4					B4					
Assemblies	Lubricate				B2			B4	B4					A4										B4					
Assemblies	Measure				$B4_1$	$A2_1$	B4				B4			A4			B2												
Assemblies	Rebuild				B4	A2	B4			B4				A4			$B2_1$					$B2_1$							
Assemblies	Recharge				B2				B4					A4															
Assemblies	Remove			$B4_1$	$B4_1$					B4				A4			B2												
Assemblies	Repair				B4	A2	B4				B4			A4			B2												
Assemblies	Replace				B4	A2		B4		B4				A4			B2		B4										
Assemblies	Rig				B4	A2		B4	B4	B4				A4															
Assemblies	Service				B2			B4	B4					A4															
Assemblies	Test			$B4_1$	$B4_1$			B4	B4					A4			$B2_2$					$B2_2$							B4
Part	Adjust			$B4_1$	$B4_1$	B2		B4	B4		B4			A4															
Part	Calibrate				B4	A2		B4	B4					A4															B4
Part	Clean				B4			B4	$B4_1$		$B4_1$			A4															
Part	Isolate Faults			$B4_1$	$B4_1$			B4	B4					A4													B4		
Part	Inspect				B4			B4	B4					A4															
Part	Install				B4	A2		B4						A4															
Part	Lubricate			$B4_1$	$B4_1$			B4	B4	B4				A4															
Part	Measure				B4			B4			B4			A4															B4
Part	Rebuild			$B4_1$	$B4_1$			B4		B4				A4															
Part	Recharge			$B4_1$	$B4_1$			B4	B4	B4				A4															
Part	Remove			$B4_1$	$B4_1$			B4		B4				A4															
Part	Repair			$B4_1$	$B4_1$	A2		B4	B4		B4			A4															
Part	Replace			$B4_1$	$B4_1$			B4		B4				A4															
Part	Rig				B4			B4	B4					A4															
Part	Service				B4			B4	B4					A4															
Part	Test			$B4_1$	$B4_1$			B4	B4					A4															B4
Part	Torque				B4			B4	B4					A4															

SELECTION GUIDE RELATING TASKS AT FOUR LEVELS OF EQUIPMENT COMPLEXITY TO
PRESENTATION COMPONENTS OF "HARD COPY" PRESENTATION COMPONENTS

Pictorial Representation									Diagrammatic Representation															Text				Condensed Data							
...rayal	View		View Type			Locators/ Identifiers			Blocks		Interconnections					Hybrid Blocks			Servicing					Mode		Style		Lists				Tables		Matrices	
Engineering Drawing	Two-Dimensional	Three-Dimensional	Assembled	Exploded	Cut-Away	Superimposed	Coordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Signal Flow	Digital Logic	Blocked Schematics	Blocked Digital Logic	Pictorial Block	Timing	Maintenance Dependency Chart	Decision Trees	Waveforms	Graphs	Directive	Deductive	Continuous	Segmented	Retrieval-Oriented	Glossary/Abbreviations	Materials	Wire	Procedures	Specialized Data	Specialized Data	Retrieval-Oriented Matrix
		B4	A4					A4			$A4_2$							$B4_2$						B4			$B4_3$			B2		$B4_3$			
					B4			A4	$A4_1$		$B4_2$					$A4_2$		$B4_1$			$B4_3$			$A4_3$			A4					$A4_3$		$A4_3$	B4
		B4						A4	$A4_2$									$A4_2$						B4			$B4_3$					$B4_3$			
A2		B4	$A4_1$	$B4_1$	$A4_1$			A4	$A4_2$				A4					$A4_2$						B4		$B4_3$	$B4_3$			B2		B4	B4		B4
A2		B4		A4	B4			A4				B4												B4			B4			B2	B4	B4			
		B4	B4					A4								B4								B4			B4			B2			B4	$B4_2$	
		B4		$A4_2$	$A4_2$			A4	B4		A4		A4					B4						B4			B4					B4			
A2		B4	A4					A4					B4					B4						B4			B4			B2		B4			
		B4	A4					A4		B4	$B4_2$					$B4_2$		B4						B4			B4			B2		B4	B4		
		B4	B4					A4			$B2_1$					$B2_1$		B4				B4	B4	B4								B4	B4		
		B4		B4				A4																B4			B4			B2					
		B4	B4					A4										B4						B4			B4					B4			B4
A2		B4			B4			A4			B4		B4					B4						B4			B4			B2	B4	B4	B4		
		B4	B4					A4			B4													B4			B4			B2		B4			
A2		B4		B4				A4			B4											B4	B4	B4			B4				B4	B4			
A2		B4		B4				A4			B4		B4					B4						B4			B4			B2		B4	B4		
A2		B4	B4					A4					B4					B4						B4			B4			B2		B4	B4		
			B4					A4			B4							B4					B4	B4			B4			B2		B4	B4		
			B4					A4			B2												B4	B4			B4					B4	B4		
		B4	B4					A4			B2							B4						B4			B4					B4			
		B4		B4				A4																B4			B4			B2		B4	B4		
		B4		B4				A4			$B2_3$	B4				$B2_3$					B4		B4	B4			B4	B4			B4	$B4_3$	$B4_3$	$B4_3$	B4
		B4	B4	B4				A4																B4			B4					B4	B4		
A2		B4		B4				A4			B2		B4					B4						B4			B4			B2		B4	B4		
		B4	B4					A4										B4						B4			B4			B2				B4	
$A2_1$	B4				B4			A4			B2													B4			B4					B4	B4		
A2	B4			B4				A4			$B2_1$					$B2_1$								B4			B4			B2	B4	B4	B4		
			B4					A4																B4			B4			B2		B4	B4		
				B4				A4			B2													B4			B4					B4			
A2	B4				B4			A4			B2													B4			B4	B4		B2		B4	B4		
A2		B4		B4				A4			B2		B4											B4			B4			B2		B4	B4		
A2		B4	B4	B4				A4																B4			B4			B2		B4	B4		
		B4	B4					A4																B4			B4			B2		B4			
		B4	B4					A4			$B2_2$					$B2_2$							B4	B4			B4			B2		B4	B4		
B2		B4	B4		B4			A4																B4			B4							B4	
A2		B4	B4					A4															B4	B4			B4					B4	$B4_2$	$B4_2$	
		B4	$B4_1$		$B4_1$			A4																B4			B4			B2		B4			
		B4	B4					A4													B4			B4			B4					B4			
		B4	B4					A4																B4			B4					B4	B4		
A2		B4						A4																B4			B4			B2		B4	B4		
		B4	B4	B4				A4																B4			B4			B2			B4		
		B4			B4			A4															B4	B4									B4		
		B4		B4				A4																B4			B4			B2		B4	B4		
		B4	B4	B4				A4																B4			B4			B2					
		B4		B4				A4																B4			B4					B4	B4		
A2		B4	B4		B4			A4																B4			B4			B2		B4	B4		
		B4		B4				A4																B4			B4			B2		B4	B4		
		B4	B4					A4																B4			B4			B2			B4		
		B4	B4					A4																B4			B4			B2			B4		
		B4	B4					A4															B4	B4			B4					B4	B4		
		B4	B4					A4																B4			B4					B4	B4		

TABLE 3-12. SELECTION GUIDE RELATING TASKS AT[illegible]
PRESENTATION COMPONENTS OF "HARD [illegible]

AVIATION ELECTRONIC TECHNICIAN (AT)

Major Work Emphasis: A/C Electronics
Reading Grade Level: 12.7
Est Wks School Reqd: 16.8

		Pictorial Representation															[illegible]				
		Portrayal					View		View Type			Locators/ Identifiers			Blocks		Interco[illegible]				
Task Actions by Levels of Complexity		Photograph	Airbrush Photo	Airbrushed Drawing	Sketch	Engineering Drawing	Two-Dimensional	Three-Dimensional	Assembled	Exploded	Cut-Away	Superimposed	Coordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	[illegible]
System	Adjust														B2					
	Inspect														B2					
	Install					A4									B2				B4	B4
	Isolate Faults															B2				
	Repair															B2	$A2_1$		B4	B4
	Service			$B4_1$	$B4_1$						B4	$B4_2$		$A4_2$		B2				
Equipment	Adjust				B4				B4					A4			$A2_1$			
	Calibrate				B4				B4					A4						
	Degauss																			
	Inspect				B4				B4					A4		B2	$A2_1$			
	Install					A4								A4			$A2_1$	B4	B4	
	Isolate Faults		$B4_1$	$B4_1$	$B4_1$			B4	B4					A4		B2	$A2_2$			
	Remove		$B4_1$	$B4_1$	$B4_1$			B4		B4				A4		B2	$A2_2$			
	Repair		$B4_1$	$B4_1$	$B4_1$			B4		B4				A4			$A2_2$			
	Test		$B4_1$	$B4_1$	$B4_1$				B4					A4			$A2_2$			
	Tune																			
Assemblies	Adjust				B4				B4					A4			$A2_1$			
	Inspect				B4											B2	$A2_1$			
	Install					B4										B2	$A2_1$		B4	
	Isolate Faults		$B4_1$	$B4_1$	$B4_1$			B4	B4					A4		B2	$A2_2$			
	Remove		$B4_1$	$B4_1$	$B4_1$			B4		B4		$B4_2$		A42						
	Repair		$B4_1$	$B4_1$	$B4_1$					B4				A4			$A2_2$			
	Replace		$B4_1$	$B4_1$	$B4_1$			B4		B4				A4						
	Service				B4				B4					A4						
	Test		$B4_1$	$B4_1$	$B4_1$				B4			B4		A4		B2	$A2_2$			
Part	Adjust				B4				B4					A4						
	Dispose of																			
	Inspect		$B4_1$		$B4_1$				B4			$B4_2$		$A4_2$						
	Install		$B4_1$	$B4_1$	$B4_1$				B4			B4		A4						
	Measure		$B4_1$	$B4_1$	$B4_1$			B4	B4			$B4_2$		$A4_2$			A2			
	Remove		$B4_1$	$B4_1$	$B4_1$			B4		B4		B4		A4			A2			
	Repair		$B4_1$	$B4_1$	$B4_1$	$B4_1$		B4		$B4_2$	$B4_2$	B4		A4						
	Replace		$B4_1$	$B4_1$	$B4_1$			B4		B4		B4		A4			A2			
	Test		$B4_1$	$B4_1$	$B4_1$			B4	B4			$B4_2$		$A4_2$			B4	B4		B4

IDE RELATING TASKS AT FOUR LEVELS OF EQUIPMENT COMPLEXITY TO OMPONENTS OF "HARD COPY" PRESENTATION COMPONENTS

		Diagrammatic Representation															Text				Condensed Data							
Locators/ Identifiers		Blocks		Interconnections					Hybrid Blocks			Servicing					Mode		Style		Lists				Tables		Matrices	
ordinate	Line and Leader	Overall Block	Detailed Block	Schematics	Wiring	Cabling	Functional Signal Flow	Digital Logic	Blocked Schematics	Blocked Digital Logic	Pictorial Block	Timing	Maintenance Dependency Chart	Decision Trees	Waveforms	Graphs	Directive	Deductive	Continuous	Segmented	Retrieval-Oriented	Glossary/Abbreviations	Materials	Wire	Procedures	Specialized Data	Specialized Data	Retrieval-Oriented Matrix
		B2							A2		A2						B4			B4						B4		
		B2							A2								B4			B4						B4		B4
		B2				B4	B4		A2		B4						B4			B4						B4		
			B2						A2				$A4_1$				$B2_1$	$B4_1$	$B4_2$	$B2_2$		B4			$B4_1$			B4
			B2	$A2_1$		B4	B4		$A2_1$	B4	B4						B4			B4	B4					B4		
	$A4_2$		B2								B4						B4			B4			B2		B4	B4		B4
	A4			$A2_1$					$A2_1$								B4			B4						B4		
	A4											B4			B4	B4	B4			B4	B4				B4	B4		
																	B4			B4					B4	B4		
	A4		B2	$A2_1$					$A2_1$								B4			B4						B4		
	A4			$A2_1$	B4	B4			$A2_1$								B4			B4			B2			B4		
	A4		B2	$A2_2$					$A2_2$	A2			B4				$B4_2$	B4	B4	$B4_2$					B4	B4		B4
	A4		B2	$A2_2$					$A2_2$								B4			B4								
	A4			$A2_2$					$A2_2$								B4			B4	B4		B2			B4		
	A4			$A2_2$					$A2_2$						B4	B4	B4			B4				A4		B4		
																	B4			B4						B4		
	A4			$A2_1$					$A2_1$			B4			B4		B4			B4						B4		
			B2	$A2_1$					$A2_1$		B4						B4			B4						B4		
			B2	$A2_1$		B4			$A2_1$		B4						B4			B4			B2			B4		
	A4		B2	$A2_2$					$A2_2$	A2		B4	B4				$B4_2$	B4	B4	$B4_2$					B4	B4		
	$A4_2$										B4						B4			B4					B4			
	A4			$A2_2$					$A2_2$								B4			B4			B2			B4		
	A4										B4						B4			B4			B2		B4	B4		
	A4										B4						B4			B4	B4		B2			B4		
	A4		B2	$A2_2$					$A2_2$			B4			B4	B4	B4			B4				A4		B4		
	A4																			B4						B4		
											B4									B4						B4		
	$A4_2$																			B4	B4		B2			B4		
	A4										B4									B4						B4		
	$A4_2$			A2								B4			B4	B4				B4						B4		
	A4			A2																B4						B4		
	A4																			B4						B4		
	A4			A2							B4									B4			B4			B4		
	$A4_2$			B4	B4		B4					B4			B4	B4				B4						B4		

5. THE SELECTION MATRIX FOR TM PHYSICAL CHARACTERISTICS

The physical characterisitcs of the media selected for technical data are determined by environmental contraints. The User-Data Match Model therefore includes a matrix constructed to permit selection of physical characteristics of media based on these constraints.

The remaining matrix in the User-Data Match Model (Table 3-13) deals with the relationships between environmental constraints (vertical axis) and the physical characteristics of the presentation media (horizontal axis). Characteristics of hard copy are described in detail, microform is given a broader treatment while audio/video media are only achnowledged. The environmental constraints column lists those aspects of the natural environment that would affect information presentation (e.g., wind, rain, heat, etc.) plus those man-made constraints that would have a similiar effect (e.g., hazardous work areas, cramped space, dim lights, etc.).

An entry in one of the cells of this matrix indicates that the physical characteristic of media identified in that column is approprite for use given the environmental constraint identified by the row title.

Definitive information on the environments in which the users work has not yet been gathered. The environments identified in this matrix are based upon data from the literature, results of the Hughes Fleet Survey, and informal discussions with cognizant Navy personnel. Many critical environments may have to be added to this matrix as more information becomes available.

Entries in the cells of this matrix are illustrative of being based upon subjective evaluation of the appropriateness of the possible environmental constraint–physical characteristic pairings. The recommendations in the complete model would be validated by field surveys.

TABLE 3-13. MATRIX SHOWING OPTIONS IMPOSED BY ENVIRONMENTAL CONSTRAINTS ON PH

Environmental Constraints			Standard (8-1/2"x11", 8"x10-1/2")	Pocket Size (5"x3", 7"x9")	Oversize (11"x15" and over)	Foldout Pages	Same Type Face	Mixed Type Face	Same Type Size	Mixed Type Size	All Capitals	Computer Printout	Single Column, One Page	Multi-Column, One Page	Type in Color	Black Tint/Shading	Drawings	Paper	Plastic	Plastic-Coated Paper	Paper/Card	Plastic	Cloth	Snap Ring (in cover)	Snap Ring (Individual)	"Perfect" Binding	Prong Fastner	Post and Screw	Portabl
			Physical Characteristics of Media																										
			Hard Copy																										
			Page Size				Typography						Format		Color			Page Material			Cover Material			Cover and Bind					
Space	User Work Area	Unrestricted			X	X																							X
Space	User Work Area	Restricted	X	X										X										X				X	
Space	User Work Area	None		X																									
Space	Tech Info Use Optional	Layout on equip.	X	X										X						X		X		X					
Space	Tech Info Use Optional	Layout on bench			X	X							X							X		X		X					X
Space	Tech Info Use Optional	None		X										X				X						X				X	
Space	Tech Info Storage	Near/with equip.	X										X							X		X		X					
Space	Tech Info Storage	Library			X	X							X					X			X		X	X					X
Space	Tech Info Storage	Centrally held			X	X							X					X			X		X	X					
Illumination	Outdoor	Shielded/shaded																X											X
Illumination	Outdoor	Full Sun																X											X
Illumination	Outdoor	Glare																X											X
Illumination	Indoor	Bright (60-100 FC)																											
Illumination	Indoor	Dim (-10 FC)					X_1		X_1									X											X
Illumination	Indoor	Glare (+100 FC)																											
Dirt	Liquid	Oil																	X			X							
Dirt	Liquid	Grease																	X			X							
Dirt	Liquid	Solvent																	X			X							
Dirt	Liquid	Dirty water																		X		X							
Dirt	Solid	Dust																X			X								
Physical	Wind	Ramp/deck		X										X					X	X		X		X					
Physical	Wind	Fan/vent	X										X					X				X		X					
Physical	Moisture	Rain	X	X									X	X						X		X		X					
Physical	Moisture	Spray	X	X									X							X		X		X					
Physical	Moisture	Humidity	X										X							X		X		X					
Physical	Moisture	Steam	X										X						X	X		X		X					
Physical	Temp	Cold (50°F and below)	X															X		X			X	X					
Physical	Temp	Hot (85°F +)																X			X		X	X					
Physical	Platform Motion	Pitching ship	X	X			X_1		X_1				X							X		X		X				X	
Physical	Platform Motion	Vehicle		X			X_1		X_1				X							X		X		X				X	
Physical	Hazard Area	Catapult launch area		X									X							X		X		X					
Physical	Hazard Area	Aircraft runup		X									X							X		X		X					
Physical	Hazard Area	Super-heat steam		X									X							X		X		X					
Noise	Outdoor	Deck																											
Noise	Outdoor	Ramp/apron																											
Noise	Indoor	Machinery																											
Noise	Indoor	Personnel																											
Noise	Indoor	Audio/P.A.																											
Noise	Indoor	Quiet																											

[1]Go to larger point type.
[2]Use with headset.

IONS IMPOSED BY ENVIRONMENTAL CONSTRAINTS ON PHYSICAL CHARACTERISTICS OF THREE MEDIA

Physical Characteristics of Media

Hard Copy																							Microform													Other	
ize	Typography						Format		Color			Page Material			Cover Material			Cover and Binding					Viewer			Film Carrier				Frame Retrieval			Illumin.			Audio Video	
over) Foldout Pages	Same Type Face	Mixed Type Face	Same Type Size	Mixed Type Size	All Capitals	Computer Printout	Single Column, One Page	Multi-Column One Page	Type in Color	Black Tint/Shading	Drawings	Paper	Plastic	Plastic-Coated Paper	Paper/Card	Plastic	Cloth	Snap Ring (in cover)	Snap Ring (Individual)	"Perfect" Binding	Prong Fastner	Post and Screw	Portable	Hand-Held Viewer	Printout Capability	Roll	Cartridge/Cassette	Aperture Card	Microfiche	Manual	Semi-automatic	Automatic	Use in Daylight	Shaded Screen	Darkened Room	Recorded Instructions	Audio/Video
X																							X		X	X	X					X		X		X	X
								X										X				X		X					X								
								X						X		X		X																		X	
X							X							X		X		X					X		X	X								X		X	
								X				X						X				X															
							X							X		X		X																			
X							X					X			X		X	X					X		X	X	X				X	X		X		X	X
X							X					X			X		X	X																		X	X
												X											X	X										X			X
												X											X	X										X			
												X											X	X										X			
	X_1		X_1									X											X											X			X
													X			X																					
													X			X																					
													X			X																					
														X		X																					
												X			X																						
								X					X	X		X		X																			
							X					X				X		X																			
							X	X						X		X		X																			
							X							X		X		X																			
							X							X		X		X																			
							X						X	X		X		X																			
												X		X			X	X																			
												X			X		X	X																			
	X_1		X_1				X							X		X		X				X															
	X_1		X_1				X							X		X		X				X															
							X							X		X		X																			
							X							X		X		X																			
							X							X		X		X																			
																																			X_2	X_2
																																				X	X

SECTION 4
USE OF THE MODEL

1. PROCEDURE FOR USING THE USER-DATA MATCH MODEL

Use of the User-Data Match Model requires input of the equipment type, user ratings, and the user environment. Recommendations concerning presentation components and physical characteristics of the TM are outputs from which specification modules can be identified.

The application of the model to the design of TMs for specific types of users involves the correct use of three types of matrices:

Equipment Type vs. Task Actions
Task Actions vs. Presentation Components
Environmental Constraints vs. Physical Characteristics of Media.

Figure 4-1 shows the application of the matrices.

Step 1 – The initial step in the process is to determine the type of hardware, and the environment in which it will be used. This determines the rating(s) that will maintain the equipment. With the rating identified, the basic categories of tasks (or "task actions") that are characteristic of his work can be derived, based on a listing of the hardware components (next step). If the rating who will be tasked with maintaining the hardware system is not obvious, check NAVPERS 18068D.

Step 2 – The equipment should first be analyzed to determine its main functional units and characteristic components. This first-cut hardware breakdown would be based on preliminary descriptive information available at the time of acquisition, and would be assisted by comparison with various sources of data on similar procurements, past experience, etc. The maintenance level (equipment, assembly, part, etc) at which these units and components would be maintained, which should be more or less self evident, would also be noted.

Step 3 – Determine the task actions associated with the rating for each equipment unit and level. This would be done in Matrix No. 1, which preselects the characteristic task categories (based on NOTAP data) for each rating, against the typical units.

Step 4 – Select the presentation component matrix appropriate for the given rating. (Note the brief description of the personnel characteristics of the rating given in the upper left hand corner of the matrix.)

Step 5 – Note the task action rows which have entries. These indicate the presentation components recommended for the given task actions. The meanings of the cell entries are (A) ideal, (B) good, (C) fair, qualified by (1) experimental evidence (2) systematic survey, (3) expert opinion, and (4) analytical judgment. All presentation components identified by entries in a task row should be used in the technical information presentation. Exceptions to this are shown by subscripts ($A2_1$) denoting either or both.

Step 6 – Identify the environment to which the hardware (and TM) will be subjected.

Step 7 – Identify the row on the environment/physical characteristics matrix which correspond to the environment(s) identified above. Note the cells in the rows which have entries. The column headings are the physical characteristics of the TM which are most applicable under the environments considered.

In the final version of the model, the final output will be recommendations concerning the selection of specification modules.

The most immediate use of the model will be by the preparers of TM specifications (and secondarily, by the TM procurement manager). The specification will subsequently provide directions concerning presentation techniques for the TM writer.

The presentation component matrices may be made either mandatory or guidance documents by the specification function. These matrices, however, are constructed in such a way as to allow a number of levels between "strictly mandatory" and "guidance only" usage. For example, the specification function may elect to make the presentation components mandatory if their utility scale code is an "A," or their source value code is a "2" or better, while other matrix entries would remain as guiding suggestions only.

The Navy TM engineer in the procurement function will employ the model when he has a requirement to procure TMs for a new piece of equipment. With the data base contained in the User-Data Match, it will be possible for him to enter into the model the type of equipment and the personnel ratings who will operate/maintain it. From this, he will get recommendations concerning presentation specifications modules best suited to that procurement.

STEP 1

- IDENTIFY SYSTEM/EQUIPMENT TYPE AND ITS USE
- IDENTIFY THE RATING(S) OF THE ASSOCIATED MAINTENANCE PERSONNEL
- IDENTIFY THE ENVIRONMENT FOR TASK PERFORMANCE

STEP 2

- PERFORM PRELIMINARY EQUIPMENT BREAKDOWN TO IDENTIFY MAIN COMPONENTS OF THE HARDWARE

EQUIPMENT TYPE AND MAINTENANCE LEVEL	TASK ACTION		
	FILL	INSPECT	ISOLATE FAULTS
AFTER STEERING SYSTEM		•	•
AIR CONDITIONING CHILL WATER SYSTEM (SUBMARINE)	•	•	•
AIRCRAFT ELEVATORS		•	•
ATMOSPHERIC EXHAUST SYSTEM		•	•
AUXILIARY AIR EJECTOR SYSTEM		•	•
AUXILIARY EXHAUST STEAM SYSTEM		•	•
AUXILIARY GLAND EXHAUST SYSTEM		•	•
AUXILIARY MACHINERY COOLING WATER SYSTEM	•	•	•

(RATING) TASK ACTIONS	
ADJUST CALIBRATE INSPECT	
INSTALL ISOLATE FAULTS REMOVE	
REPAIR TEST TUNE	

STEP 3

DETERMINE EQUIPMENT TYPE AND MAINTENANCE LEVEL, IDENTIFY TASK ACTIONS TO BE PERFORMED

SE
EN
TA
CE

PRESENTATION COMPONENTS OR TECHNIQUES

(RATING) TASK ACTIONS	PHOTOGRAPH	AIRBRUSH PHOTO	AIRBRUSHED DRAWING	SKETCH	ENGINEERING DRAWING	TWO-DIMENSIONAL	THREE-DIMENSIONAL
ADJUST				B4			
CALIBRATE				B4			
INSPECT				B4			
INSTALL				A4			
ISOLATE FAULTS		$B2_3$	$B4_1$	$A4_1$			B4
REMOVE		$B4_1$	$B4_1$	$B4_1$			B4
REPAIR		$B4_1$	$B4_1$	$B4_1$			B4
TEST		$B4_1$	$B4_1$	$B4_1$			
TUNE							

STEPS 4 AND 5

SELECT PRESENTATION COMPONENTS OR TECHNIQUES FOR THE TASK ACTIONS SHOWN ON PRECEDING MATRIX

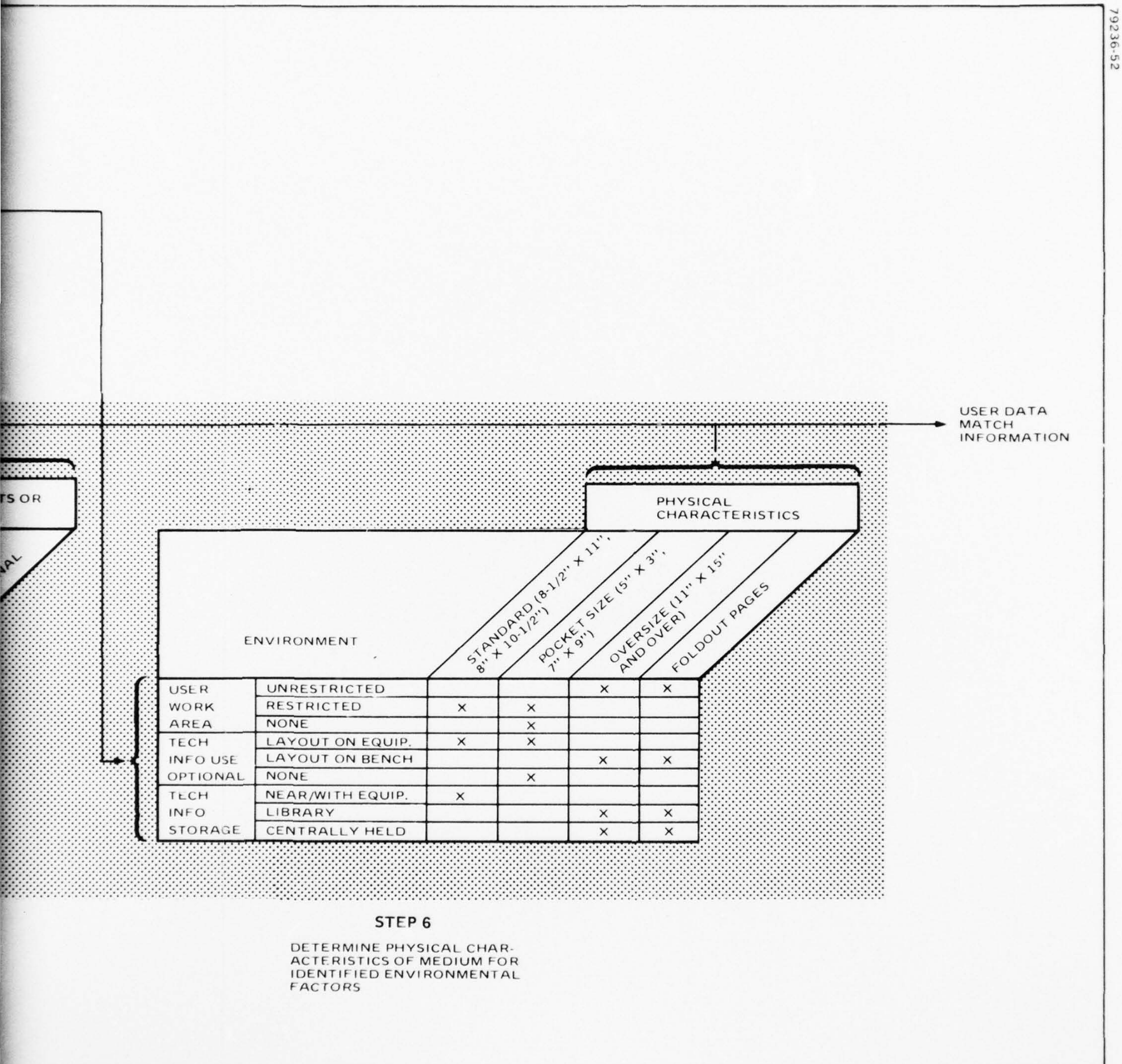
ENVIRONMENT		STANDARD (8-1/2" X 11", 8" X 10-1/2")	POCKET SIZE (5" X 3… 7" X 9")	OVERSI… AND O…
USER	UNRESTRICTED			X
WORK	RESTRICTED	X	X	
AREA	NONE		X	
TECH	LAYOUT ON EQUIP.	X	X	
INFO USE	LAYOUT ON BENCH			X
OPTIONAL	NONE		X	
TECH	NEAR/WITH EQUIP.	X		
INFO	LIBRARY			X
STORAGE	CENTRALLY HELD			X

STEP 6

DETERMINE PHYSICAL CHARACTERISTICS OF MEDIUM FOR IDENTIFIED ENVIRONMENTAL FACTORS

Figure 4-1. Procedure for Using the Matrices in
developed for all Navy ratings, this model would c
Navy TM engineer of the best presentation compo
intended user. Note: Matrices are for illustration
in its completed form.

2



ENVIRONMENT		STANDARD (8-1/2" X 11", 8" X 10-1/2")	POCKET SIZE (5" X 3", 7" X 9")	OVERSIZE (11" X 15" AND OVER)	FOLDOUT PAGES
USER WORK AREA	UNRESTRICTED			X	X
	RESTRICTED	X	X		
	NONE		X		
TECH INFO USE OPTIONAL	LAYOUT ON EQUIP.	X	X		
	LAYOUT ON BENCH			X	X
	NONE		X		
TECH INFO STORAGE	NEAR/WITH EQUIP.	X			
	LIBRARY			X	X
	CENTRALLY HELD			X	X

Figure 4-1. Procedure for Using the Matrices in the User-Data Match Model. When completely developed for all Navy ratings, this model would contain sufficient data to enable selection by the Navy TM engineer of the best presentation components and techniques for matching a TM to the intended user. Note: Matrices are for illustration purposes only, and do not represent the model in its completed form.

APPENDIX A
CORRELATION COEFFICIENTS FOR ANALYSIS OF PERSONNEL CARACTERISTICS

Appendix A

CORRELATION COEFFICIENTS FOR ANALYSIS OF PERSONNEL CHARACTERISTICS

A series of person product-moment correlations and point-biserial correlations were performed on the data collected from NOTAP. Table A-1 provides a summary of the person product-moment correlations and Table A-2 a summary of the point-biserial correlations comparing the electronic versus the nonelectronic ratings on six factors. A discussion of the meanings of these correlation coefficients follows:

Person Product-Moment Correlations. The person product-moment correlation is used with interval scales. It indicates the degree to which two sets of scores are linearly related; that is, to what extent we can predict with a linear equation a person's score on one variable if his score on another is known. This technique is generally used with individual scores rather than ranks. The results of these correlations are shown below.

GCT-ART ($r = 0.98$). This correlation indicates that those ratings which have high scores in the verbal reasoning test also perform very well (on the average) on the arithmetic reasoning test.

GCT-MECH ($r = 0.56$). This correlation indicates a positive relationship between performances on the verbal reasoning test and the mechanical knowledge test. The mechanical knowledge test average scores do not vary greatly across ratings. Mechanical aptitude would probably have varied more and shown a stronger correlation with GCT.

GCT-School ($r = 0.68$). This correlation is an indicant that those ratings with higher average verbal reasoning abilities are seen by their members as requiring the most Navy school training.

GCT-Experience ($r = -0.59$). The negative correlation obtained in this case contrasts sharply with the GCT-school correlation discussed above. It appears that those ratings of higher average verbal reasoning abilities generally feel that little Navy work experience is required for their job performance. This finding is in correspondence with the negative school-experience correlation discussed below.

GCT-OJT ($r = 0.25$). This correlation indicates a tendency for ratings of higher average verbal reasoning ability to believe that they require relatively more OJT on their jobs than other ratings. On the whole, OJT requirements seem independent of reasoning ability, training, or Navy experience.

ARI-MECH (r=0.59). The same situation occurs in this case as in the GCT-MECH correlation above. This is not surprising since the GCT and ARI are so highly co-related.

ARI-School (r=0.70). This correlation indicates that those ratings with higher average arithmetic reasoning abilities are seen by their members as requiring the most Navy school training.

ARI-Experience (r=0.56). As in the case of GCT-experience, it seems that those ratings of higher average arithmetic reasoning abilities usually feel that relatively little Navy work experience is required for their job performance.

ARI-OJT (r=0.29). Again, list the case of GCT, this correlation shows a tendency for ratings of higher average arithmetic reasonong ability to believe that they require somewhat more OJT on their jobs than other ratings.

MECH-School (r=0.34). This correlation indicates that there is a tendency for ratings with higher mechanical test scores to feel that they require more Navy school training.

MECH-Experience (r=0.16). This small negative correlation shows that there is little relationship between scores on the mechanical test and perceived need for Navy experience for job performance.

MECH-OJT (r = 0.56). This correlation indicates a positive relationship between performance on the mechanical knowledge test and the perceived requirement for on the job training.

School-Experience (r = 0.40). This negative correlation indicates that there is a tendency for ratings to stress their requirements either for Navy school training or for Navy work experience but not both.

School-OJT (r=0.09). The small correlation indicates that one may not predict a rating's stated requirement for Navy school training from knowledge of the standard requirements for on the job training, and vice versa. The two different kinds of requirements do not necessarily substitute for each other.

Experience -OJT (r=0.05). This small correlation is similiar to the case of school-OJT discussed above. Knowledge of rating's average statement of required Navy experience does not permit a prediction of the stated requirement for on the job training.

TABLE A-1. PERSON PRODUCT-MOMENT CORRELATIONS BASED ON NOTAP DATA

	GCT	ARI	MECH	School	Experience
ARI	0.98				
MECH	0.56	0.59			
School	0.68	-0.56	0.34		
Experience	-0.59	-0.56	-0.16	-0.40	
OJT	0.25	0.29	0.56	0.09	-0.05

Point-Biserial Correlations. The point-biserial is a specific type of coefficient designed to be used in correlating two variables when one of the variables is a dichotomy such as being male versus female or a farmer versus not being a farmer, etc. When the rating groups are divided into electronic versus non-electronic orientations, point-biserial correlations may be computed using their test scores and opinions as indicated in the NOTAP data bank. The results of these correlations are shown in Table A-2.

There are three very high point-biserial correlation coefficients in this table. They pertain to the GCT score, the ARI score, and the perceived need for Navy schooling. It is clear that recruits scoring highly on the GCT test and the ARI are usually assigned to electronic-type ratings. Furthermore, these high scoring individuals are sent to schools of greater duration. Whether these results are based upon individuals' preferred career objectives or upon the needs of the Navy is not clear from this data.

The negative correlation with perceived requirement for Navy experience indicates that the electronics-oriented ratings do not see a necessity for many years in the Navy in order to perform their required tasks. It is evident that the perceived requirement for Navy school substitutes for this experience. The correlation with the mechanical knowledge test is quite small and with OJT, is inconsequential. These two factors are apparently not predictable from knowing whether or not a rating group is classified as electronic or non-electronic in orientation.

TABLE A-2. POINT-BISERIAL CORRELATIONS – ELECTRONIC VS NON-ELECTRONIC RATINGS

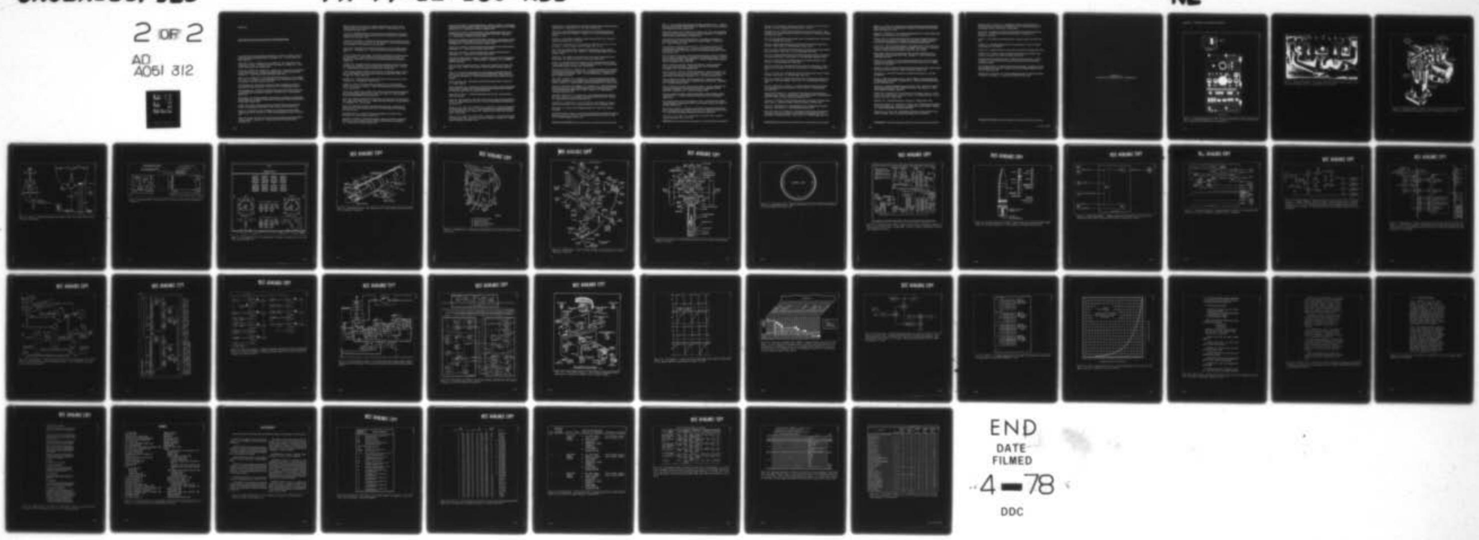
GCT	ARI	MECH	Schooling	Experience	OJT
0.84	0.87	0.35	0.73	-0.56	0.06

APPENDIX B
BIBLIOGRAPHY FOR LIST OF HUMAN FACTORS PRINCIPLES

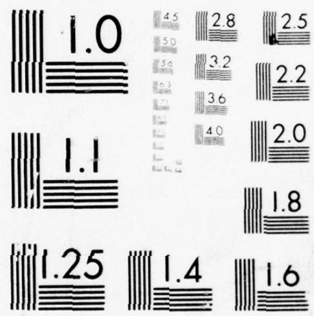
AD-A051 312 HUGHES AIRCRAFT CO FULLERTON CALIF GROUND SYSTEMS GROUP F/G 5/9
PRELIMINARY NTIP SYSTEM CONCEPT AND ALTERNATIVE CONFIGURATIONS.--ETC(U)
JAN 78 N00600-76-C-1352

UNCLASSIFIED FR-77-12-150-ADD NL

2 OF 2
AD
A051 312



END
DATE
FILMED
4-78
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Appendix B

BIBLIOGRAPHY FOR LIST OF HUMAN FACTORS PRINCIPLES

Army Material Command. Military Specification. Manuals, Technical: General Requirements (MIL-M-0038784A(TM)). Washington, D.C.: Army Material Command, May 1974.

Ayoub, M.A., Cole, J.L., Sakala, M. K., & Smillie, R.J. Job Performance Aids: Assessment of Needs. A Literature Review (Final Report). Raleigh, N.C.: North Carolina State University, October 1974.

Ayoub, M.A., Smillie, R.J., Edsall, J.C., & Muller, W.G. Assessment and Evaluation of Job Performance Aids: A Simulation Approach (Part I, Executive Summary). Raleigh, N.C.: North Carolina State University, April 1976.

Baker, C.A., & Grether, W.F. Visual Presentation of Information. In C.T. Morgan, J.S. Cook, III, A. Chapanis, & M.W. Lund (Eds.), Human Engineering Guide to Equipment Design. New York: McGraw-Hill, 1963.

BioTechnology, Inc. Excerpt From a Study to Design a Shipboard Evaluation of Experimental Technical Manuals. Falls Church, VA: BioTechnology, undated.

BioTechnology, Inc. A Method for Selecting Training or Maintenance Aids for Obtaining Technician Performance Capability. Falls Church, VA: BioTechnology, March 1974.

Blankenhiem, J.B. Technical Manuals, Human Factors, and System Effectiveness. Paper presented at the System Performance Effectiveness Conference (SPECON-5), 22 May 1969. (AD 691 418)

Booher, H.R. Relative Comprehensibility of Pictorial Information and Printed Words in Proceduralized Instructions. Human Factors, 1975, 17(3), 266-277.

Braby, R. An Evaluation of Ten Techniques for Choosing Instructional Media (TAEG Report No. 8). Orlando, FL: Naval Training Equipment Center, December 1973.

Braby, R. Summary of Issues and Tentative Recommendations Relating NTIPP to Training (DRAFT). Orlando, FL: Training Analysis and Evaluation Group, February 1977.

Byrd, K., Kidd, J.S., & Price, H.E. Analysis and Evaluation of Navy Avionics Manuals (Report No. NAVTRADEVCEN 69-C-0301-1). Falls Church, VA: Bio-Technology, December 1970.

Carte, J.A. Typographic Noise Can Detract From the Readability of Documents. Paper presented at the 22nd International Technical Communication Conference, Anaheim, CA, May 14-17, 1975.

Carter, J.F., & Carrier, C. The Role of Selected Organizational Variables in Learning From Written Instruction (TR 74-31). San Diego, CA: Navy Personnel Research and Development Center, May 1974. (AD 780 789)

Carver, R.P. Measuring the Reading Difficulty Levels of Navy Training Manuals (TR Phase I). Washington, D.C.: American Institutes for Research, September 1973.

Center for Educational Technology. Interservice Procedures for Instructional Systems Development: Executive Summary and Model (NAVEDTRA 106A). Fort Benning, GA: Interservice Committee for Instructional Systems Development, August 1975.

Chenzoff, A.P. Evaluative Study of the Content and Display of New and Existing Technical Data to Support Air Force Maintenance (AFHRL-TR-73-47). Valencia, PA: Applied Sciences Associates, November 1973. (AD 915 233)

Chief of Naval Technical Training. Procedures for the Planning, Design, Development, and Management of Navy Technical Training Courses (CNTT-A10). NAS Memphis, TN: CNTT, April 1976.

Coviello, J.W. Troubleshooting Procedure Development Writer's Guide (C-141A). Pittsburgh, PA: Westinghouse, February 1974.

Curran, T.E. Survey of Technical Manual Readability and Comprehensibility (NPRDC TR 76-xx). San Diego, CA: Navy Personnel Research and Development Center, August 1976.

Curran, T.E., Thomas, G.S., & Duffy, T.M. Review of Technical Manual Readability and Comprehensibility (Office Review Draft). San Diego, CA: Navy Personnel Research and Development Center, July 1975.

Davis, R.M. Effective Technical Communications Copy Preparation and Reproduction – Experiment I (AFIT TR 71-1). Wright-Patterson AFB, OH: Air Force Institute of Technology, 1971. (AD 722 054)

Davis, R.M. Effective Technical Communications, Expression – Experiment II (AFIT TR 72-3). Wright-Patterson AFB, OH: Air Force Institute of Technology, 1972 (AD 741 753)

Decision Science, Inc. Toward a Measure of Pictogram Instructional Value. San Diego, CA: Decision Science, April 1976.

Department of Defense. Military Specification, Manuals, Technical: Equipment and Systems Content Requirements for (MIL-M-15071G(NAVY)). Washington, D.C.: Department of Defense, August 1969.

Department of Defense. Military Specification. Manuals, Technical: Functionally Oriented Maintenance Manuals (FOMM) for Equipment and Systems (MIL-M-24100B). Washington, D.C.: Department of Defense, January 1974a.

Department of Defense. Military Standard. Human Engineering Design Criteria for Military Systems, Equipment and Facilities (MIL-STD-1472B). Washington, D.C.: Department of Defense, December 1974b.

Department of Defense. Military Standardization Handbook. Functionally Oriented Maintenance Manual (FOMM) Writer's Guide for MIL-M-24100B (MIL-HDBK-242). Washington, D.C.: Department of Defense, October 1974c.

Department of Defense. Technical Manual Writing Handbook (MIL-HDBK-63038-1). Washington, D.C.: Department of Defense, March 1976a.

Department of Defense. Technical Writing Style Guide (MIL-HDBK-63038-2). Washington, D.C.: Department of Defense, March 1976b.

Department of Navy, Bureau of Ships. Preparation Guide for Electronic Equipment Technical Manuals (Section 4 – Troubleshooting). Washington, D.C.: NAVSHIPS 94500(A), May 1962.

Dieter, B. The Company Style Guide: A Survey and Analysis of Its Format, Content, and Utility. Master of Arts Thesis, California State University, Fullerton, 1973.

Duffy, T. An Overview Organization of a Comprehensive Readability R&D Program and the Current Navy Expressed Interest in Readability. Paper presented at a meeting. San Diego, CA: Navy Personnel Research and Development Center, undated.

Dustin Associates, Inc. Functionally Oriented Maintenance Manual. Santa Ana, CA: Dustin, undated.

Dustin Associates, Inc. Comparative Analysis of Functionally Oriented Maintenance Manuals (MIL-M-24100B) and Conventional Maintenance Manuals (MIL-M-38784) (CC-OP-PI-I). Santa Ana, CA: Dustin, March 1975.

Eames, R.D., & Starr, J. Technical Publications and the User. Human Factors, 1965, 7(4), 363-369.

Foley, J.P. Task Analysis for Job Performance Aids and Related Training (AFHRL-TR-72-73). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, November 1973.

Folley, J.D., Jr., Joyce, R.P., Mallory, W.J., & Thomas, D.L. Fully Proceduralized Job Performance Aids: Volume I – Draft Specification for Organizational Maintenance (AFHRL-TR-71-53). Valencia, PA: Applied Science Associates, December 1971a. (AD 740 903)

Folley, J.D., Jr., Joyce, R.P., Mallory, W.J., & Thomas, D.L. Fully Proceduralized Job Performance Aids. Volume II – Developer's Handbook. Valencia, PA: Applied Science Associates, December 1971b.

Gulliford, N.L. Current Research on the Relative Effectiveness of Selected Media Characteristics. Natrona Hts., PA: DGA, Inc., October 1973.

Haller, D.K. Navy SORTS (Shipboard Organizational Troubleshooting System) (Customer Presentation Handout). Pt. Mugu, CA: Grumman Aerospace Corp., undated.

*Holmes, G. The Relative Legibility of Black Print and White Print. Journal of Applied Psychology, 1931, 15, 248-251.

*Howes, D.H., & Solomon, R.L. Visual Duration Threshold as a Function of Word-Probability. Journal of Experimental Psychology, 1951, 41, 401.

IBM. Focus on the Trained Man. Design of Training Systems, Phase I Report – Volume I TAEG Report No. 12). Orlando, FL: Naval Training Equipment Center, December 1973.

*Isaacs, D.L. The Effects on Learning of the Color Coding of Pictorial Stimuli. Bloomington, IN: Indiana University AV Center, September 1969.

James, F.W. Job Performance Aid Methods. (For Job Guide Manuals and Other Formats) DSPD Report No. 75-1). Wright-Patterson AFB, OH: Air Force Packaging Evaluation Agency, October, 1975. (AD 016 761)

Johnson, F.J., Martin, A.C., & Meyer, W.J. A Critical Evaluation of the Technical Data Development Processes Required for the Preparation of Technical Manuals and Training for Maintenance. Task I – Process Identification. Annandale, VA: REM Company, June 1975.

Joyce, R.P., Chenzoff, A.P., & Mulligan, J.F. Fully Proceduralized Job Performance Aids: Handbook for JPA Managers and Training Specialists (AFHRL-TR-73-43(III)). Valencia, PA: Applied Science Associates, December 1973. (AD 775 706)

Joyce, R.P., Chenzoff, A.P., Mulligan, J.F., & Mallory, W.J. Fully Proceduralized Job Performance Aids. Draft Military Specification for Organizational and Intermediate Maintenance (AFHRL-TR-73-43(1)). Valencia, PA: Applied Science Associates, December 1973.

Joyce, R.P., Folley, J.D., Jr., & Elliott, T.K. Fully Proceduralized Job Performance Aids. Volume III – JPA Manager's Handbook (AFHRL-TR-71-53). Valencia, PA: Applied Science Associates, December 1971.

*Katzman, N., and Hyenhuis, J. Color vs. Black and White Effects on Learning, Opinion, and Attention. AV Communication Review, 1972, 20 (Spring), 16-28.

McCormick, E.J. Human Factors Engineering (2nd ed.). New York: McGraw-Hill, 1964.

McDonnell Aircraft Company. Aircraft Troubleshooting System (ATS) Development Program Final Report. Volume II – Appendices (Report No. P.S. 895). St. Louis, MO: McDonnell Douglas, March 1975.

*Document not reviewed; citation extracted from a document that was reviewed.

Miller, L. Navy Technical Manual System (NTMS) Working Paper No. 1. Preliminary Human Factors R&D Plan (CMD-01-75). Bethesda, MD: Naval Ship Research and Development Center, January 1975.

Miller, R.B., Folley, J.D., Jr., Smith, P.R., & Swain, A.D. Survey of Human Engineering Needs in Maintenance of Ground Electronics Equipment. Pittsburgh, PA: American Institute for Research, February 1954.

National Security Industrial Association (Ed.). Proceedings of Symposium of Equipment Manuals – The Third Essential to Combat Readiness. Washington, D.C.: NSIA, 19-20 March 1968.

National Security Industrial Association (Ed.). Proceedings of Symposium on and Techniques. Washington, D.C.: Technical Publications Panel, Logistics Management Advisory Committee (LoMAC), National Security Industrial Association, January 1973.

Naval Air Systems Command. Technical Manual Preparation Guide for Technical Writers, Editors, and Illustrators. Management and Procedures Manual – Preliminary (NAVAIR 00-25-700). Washington, D.C.: NAVAIR Technical Documentation Policy and Programs Office, June 1976.

Naval Air Systems Command. Military Specification. Manuals, Technical: 16-mm Silver Halide Microfilm: Requirements for (MIL-M-81930(AS)). Washington, D.C.: NAVAIR, February 1974.

Naval Air Systems Command. Military Specification. Manuals, Technical: Aircraft, Equipment, and Component Maintenance, Preparation of (microform compatible) (MIL-M-81928(AS)). Washington, D.C.: NAVAIR, February 1975a.

Naval Air Systems Command. Military Specification. Manuals, Technical: General Preparation of (microform compatible) (MIL-M-81927(AS)). Washington, D.C.: NAVAIR, February 1975b.

Naval Air Systems Command. Military Specification. Manuals, Technical: Illustrated Parts Breakdown, Preparation of (microform compatible) (MIL-M-81929(AS)). Washington, D.C.: NAVAIR, February 1975c.

Naval Air Systems Command. Technical Manuals to a Work Package Concept. Washington, D.C.: NAVAIR Technical Documentation Policy and Programs Office, 1976.

Navy Personnel Research and Development Center. Technical Manual Graphic Comprehensibility: Classification Scheme and Graphics Catalog. San Diego, CA: NPRDC, October 1976.

Olson, G.M., & Laxar, K. Differences in the Speed of Mentally Processing Displays Containing Information About "Right" and "Left" (Report No. 725). Groton, CT: Naval Submarine Medical Research Laboratory, August 1972.

*Paterson, D.G., & Tinker, M.A. Black Type Versus White Type. Journal of Applied Psychology, 1931, 15, 241-247.

*Document not reviewed; citation extracted from a document that was reviewed.

*Payne, D.E. Readability of Typewritten Material: Proportional Versus Standard Spacing. Journal of Typographic Research, 1967, 1, 125-136.

Peterson, D.G., Jr. MIL-STD-847-A and How We Learned to Live With It. Paper presented at the 22nd International Technical Communication Conference, Anaheim, CA, May 14-17, 1975.

Post, T.J. Develop Optimum Performance Aids for Troubleshooting. Falls Church, VA: BioTechnology, Inc., undated.

Post, T.J. Guide for Selecting Formats and Media for Maintenance Information (DRAFT). Falls Church, VA: BioTechnology, October 1975a.

Post, T.J. System Conditions Affecting Format and Media Used to Present Maintenance Information. Falls Church, VA: BioTechnology, May 1975b.

Post, T.J. Technical Manual Formats and Media Warranted by System Conditions: A Substantiation Review. Falls Church, VA: BioTechnology, September 1975c.

Post, T.J. A Plan to Define Usability Problems for Technical Manuals. Falls Church, VA: BioTechnology, Inc., March 1976.

Post, T.J., & Price, H.E. Development of Innovative Job Aid Concepts. Volume II Presentation Principles for Job Aids. Falls Church, VA: BioTechnology, May 1972.

Post, T.J., & Price, H.E. Development of Optimum Performance Aids for Troubleshooting. Falls Church, VA: BioTechnology, April 1973.

Post, T.J., & Price, H.E. Requirements and Criteria for Improving Reading Comprehension of Technical Manuals. Falls Church, VA: BioTechnology, November 1974.

Post, T.J., Price, H.E., & Diffley, G. A Guide for Selecting Formats and Media for Presenting Maintenance Information. Falls Church, VA: BioTechnology, November 1976.

Potter, N.R. & Thomas, D.L. Evaluation of Three Types of Technical Data for Troubleshooting. Volume I – Study Results and Project Summary. Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, 1976.

*Powers, S. The Effect of Three Typesetting Styles on the Speed of Reading Newspaper Content. Unpublished Master's thesis, University of Florida, 1962.

Price, H.E. Development of a Draft Specification for Technical Manual Quality Assurance. Falls Church, VA: BioTechnology, December 1975.

Price, H.E., Post, T.J., & Kolsrud, G. Development of Information Measurement Techniques for Quality Assurance of Navy Aircraft Maintenance Jobs. Part I. Research and Development effort. Falls Church, VA: BioTechnology, June 1971.

*Document not reviewed; citation extracted from a document that was reviewed.

Rigby, L.V., & Gibbs, V.E. Measurement of Reader Satisfaction by Questionnaire. Paper presented at the 19th International Technical Communications Conference, Boston, MA, May 10-13, 1972.

Rogers, J.G. & Pegden, C.D. Formatting and Organization of a Human Engineering Standard. Human Factors, 1977, 19(1), 55-61.

*Rohwer, W.D., Jr. Social Class Differences in the Role of Linguistic Structures in Paired-Associate Learning: Elaboration and Learning Proficiency (Contract OE-6-10-273). Washington, D.C.: Office of Education, November 1967.

Roscoe, S.N. Man as a Precious Resource: The Enhancement of Human Effectiveness in Air Transport Operations (ARL-74-6/AFOSR-74-4). Savoy, IL: University of Illinois Aviation Research Laboratory, May 1974. (AD 785 368)

Sakala, M.K. Effects of Format Structure, Sex, and Task Familiarity on the Comprehension of Procedural Instructions. Raleigh, NC: North Carolina State University, June 1976.

Scanlan, L.A., & Carel, W.L. Human Performance Evaluation of Matrix Displays: Literature and Technology Review (AMRL-TR-76-39). Culver City, CA: Hughes Aircraft Co., June 1976.

Schaffer, G.E. (Ed.). Format and Style Guide for Development of S-3 Organizational Maintenance Manuals (TMI-22). Lockheed-California, August 1972.

Shimberg, H.L. Advanced Techniques in Technical Documentation. July 1962. (AD 690 911)

Shonyo, C. Signs and Displays Systems: Graphic Design and Human Engineering (A bibliography with abstracts). Springfield, VA: National Technical Information Service, November 1975.

Shriver, E.L. Fully Proceduralized Job Performance Aids: Guidance for Performing Behavioral Analyses of Tasks (AFHRL-TR-75-38). Falls Church, VA: URS/ Matrix Research Company, June 1975.

Sinaiko, H.W., & Buckley, E.P. Human Factors in the Design of Systems. In H.W. Sinaiko (Ed.), Selected Papers on Human Factors in the Design and Use of Control Systems. New York: Dover, 1961.

Singleton, W.T. Man-Machine Systems. Baltimore: Penguin Books, 1974.

Smillie, R.J., Edsall, J.C., Ayoub, M.A., & Muller, W.G. Assessment and Evaluation of Job Performance Aids: A Simulation Approach (Part II, Main Report). Raleigh, NC: North Carolina State University, April 1976.

*Stanton, F.N., & Burtt, H.E. The Influence of Surface and Tint of Paper on the Speed of Reading. Journal of Applied Psychology, 1935, 19, 683-693.

*Document not reviewed; citation extracted from a document that was reviewed.

Steinmann, H.J., & Larson, O.A. Investigation of Rate-Controlled Speech for Training Applications (TR 74-6). San Diego, CA: Navy Personnel Research and Development Center, October 1973. (AD 769 689)

Straly, W.H., & Dibelka, G.S. PIMO Troubleshooting Aid Preparation Guidelines. Volume VII – Project PIMO Final Report (TR-69-155). Chatsworth, CA: Serendipity, May 1969.

Teplitz, A. The Design of Microfiche Systems. Human Factors, 1970, 12(2), 225-233.

*Tinker, M.A. Prolonged Reading Tasks in Visual Research. Journal of Applied Psychology, 1955, 39, 444-446.

*Tinker, M.A. Legibility of Print. Ames, Iowa: Iowa State University Press, 1963.

*Tolliver, D.L. A Study of Color in Instructional Materials and Its Effect Upon Learning. Lafayette, IN: Purdue University, March 1972.

Training Analysis and Evaluation Group. BE&E Microfiche Study Plan – Phase II. Orlando, FL: TAEG, Basic Electricity and Electronics School, Service School Command, undated.

Tufts College, Institute for Applied Experimental Psychology. Handbook of Human Engineering Data (rev. 2nd ed.). NavExos P-643, Human Engineering Report SDC 199-1-2a, November 1952.

Woodson, W.E., & Conover, D.W. Human Engineering Guide for Equipment Designers (2nd ed.). Berkeley, CA: University of California Press, 1964.

*Document not reviewed; citation extracted from a document that was reviewed.

APPENDIX C
EXAMPLES OF PRESENTATION COMPONENTS

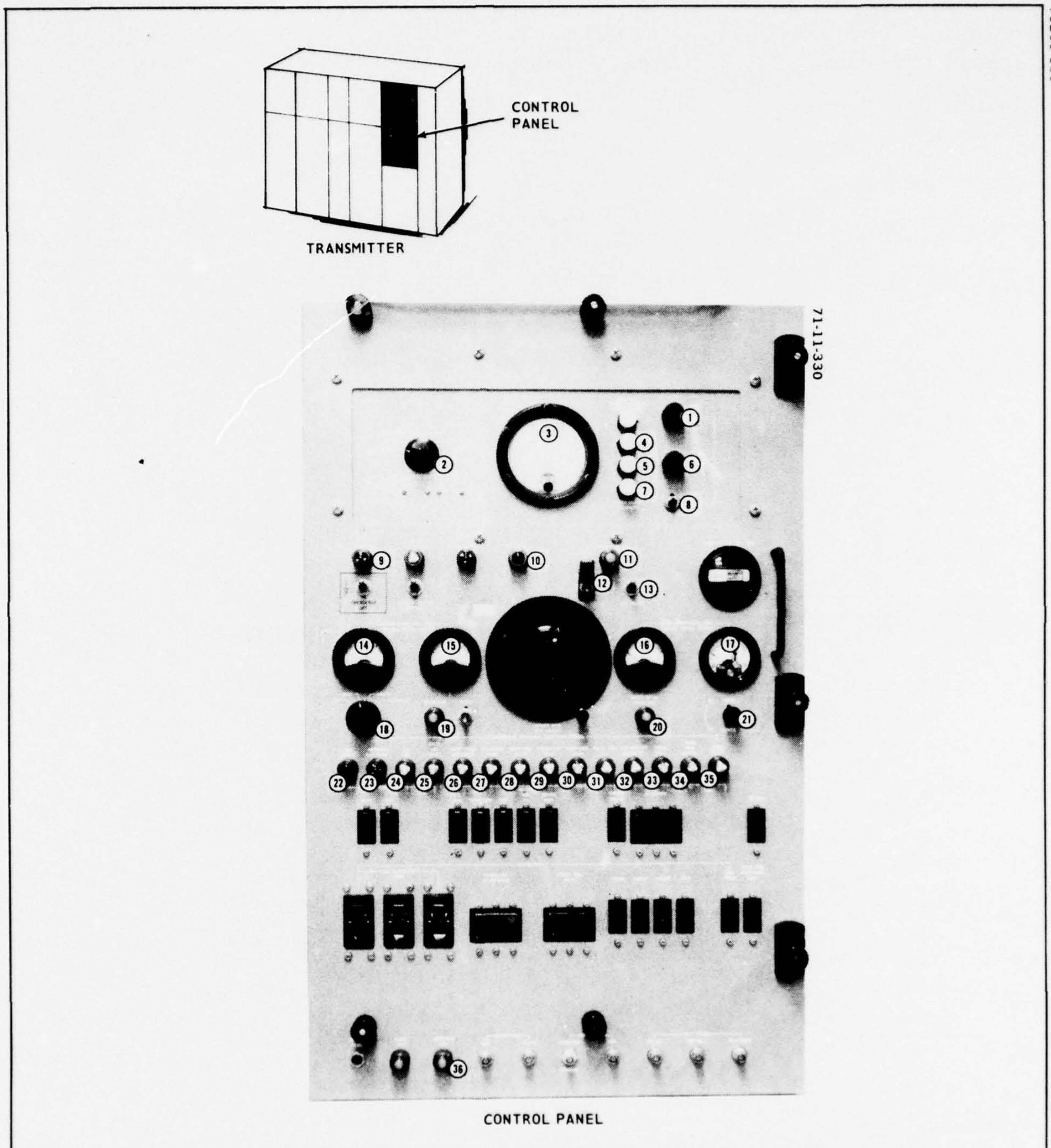
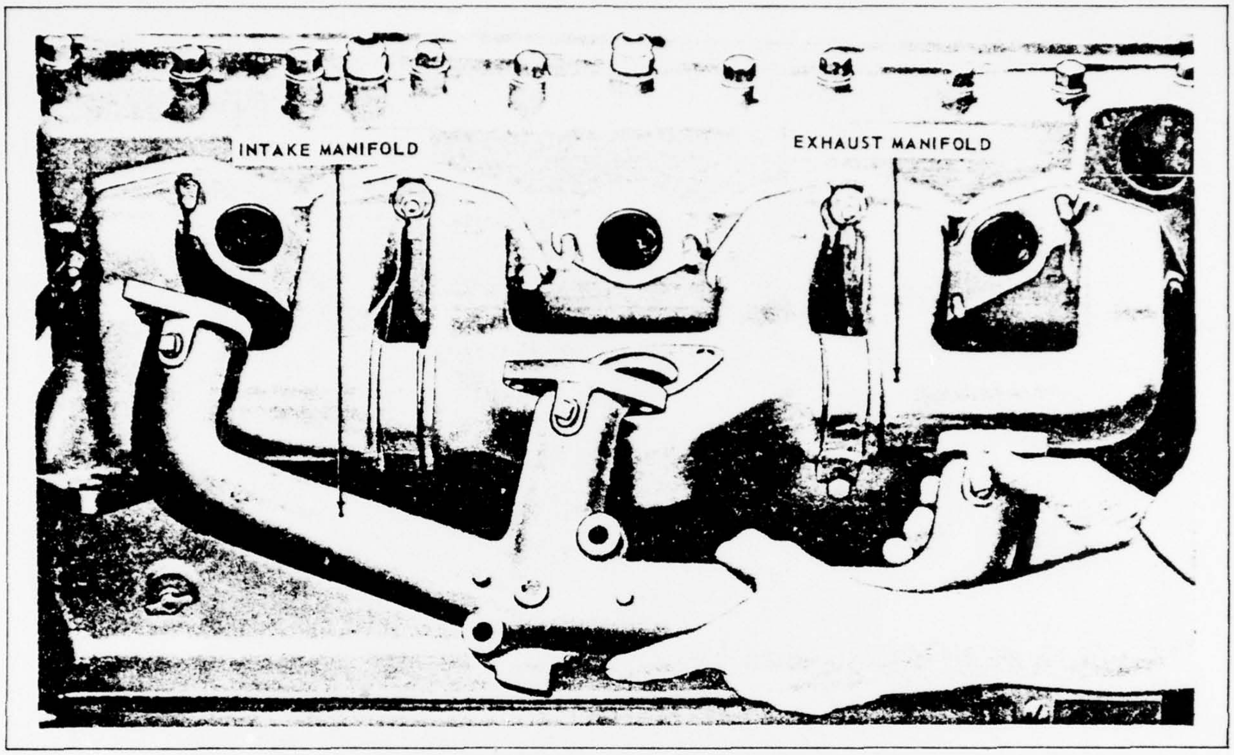
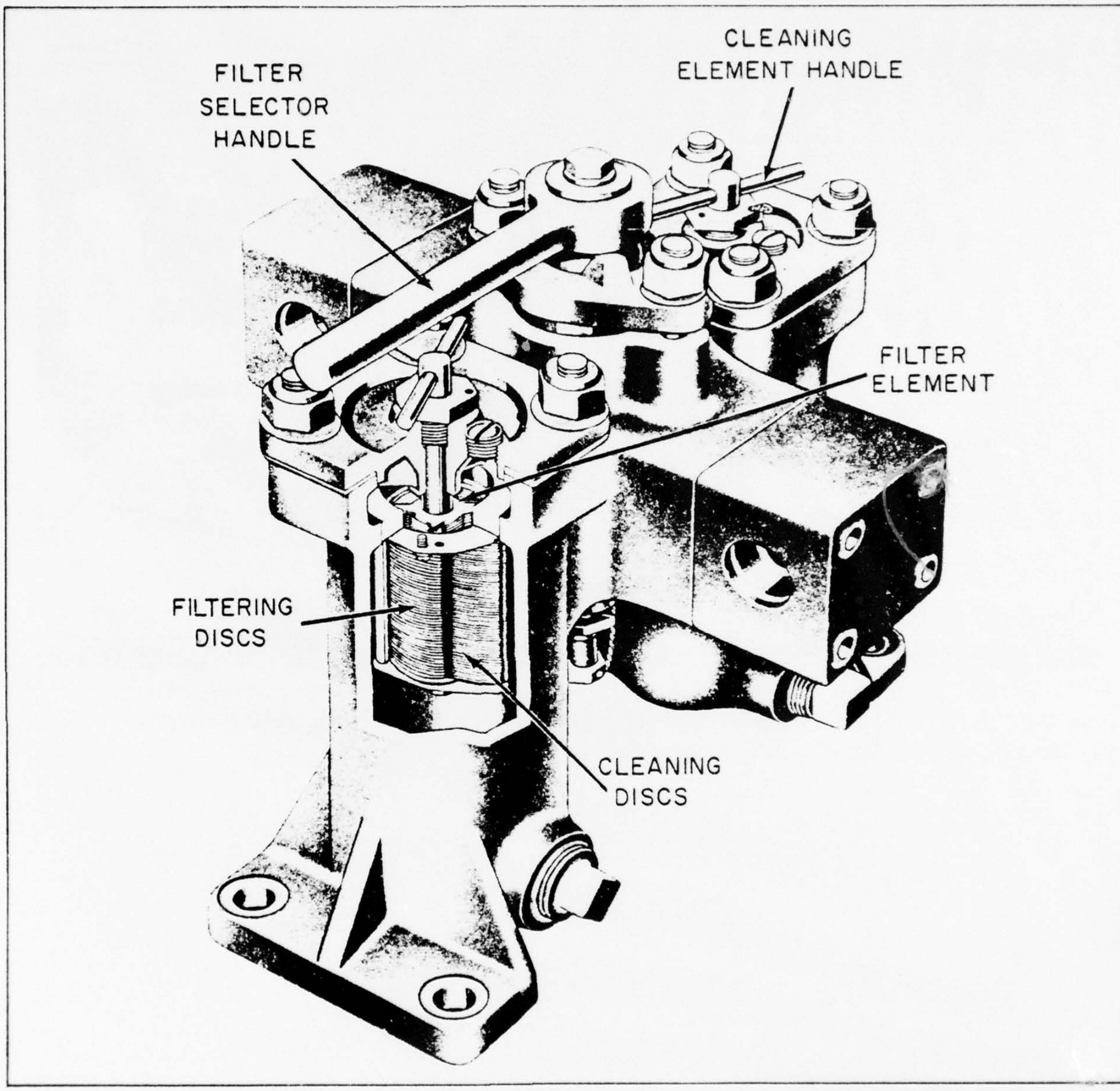


Figure C-1. Typical Photograph Used in TMs. Numbers (as shown here) or other artworked callouts may be added for closer correlation with accompanying text.



79236-111

Figure C-2. Airbrushed Photograph. A photograph with details enhanced, and/or irrelevant material obliterated, by application of ink or coloring agents from a spray gun.



7926-12

Figure C-3. Airbrushed Drawing. A sketch or engineering drawing with details enhanced, and/or irrelevant material obliterated, by application of ink or coloring agents from a spray gun.

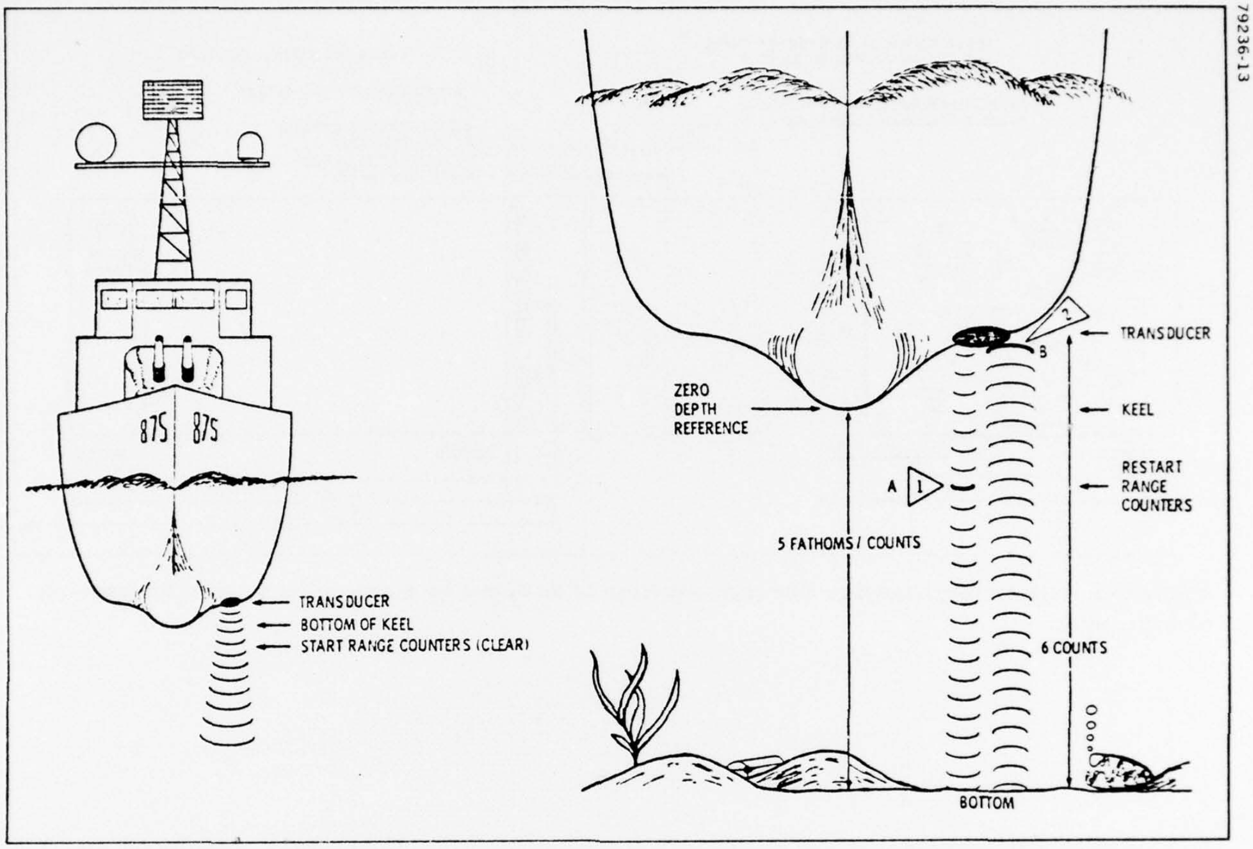


Figure C-4. Sketch. A freehand drawing illustrating important features of an object without concern for precision of dimensions.

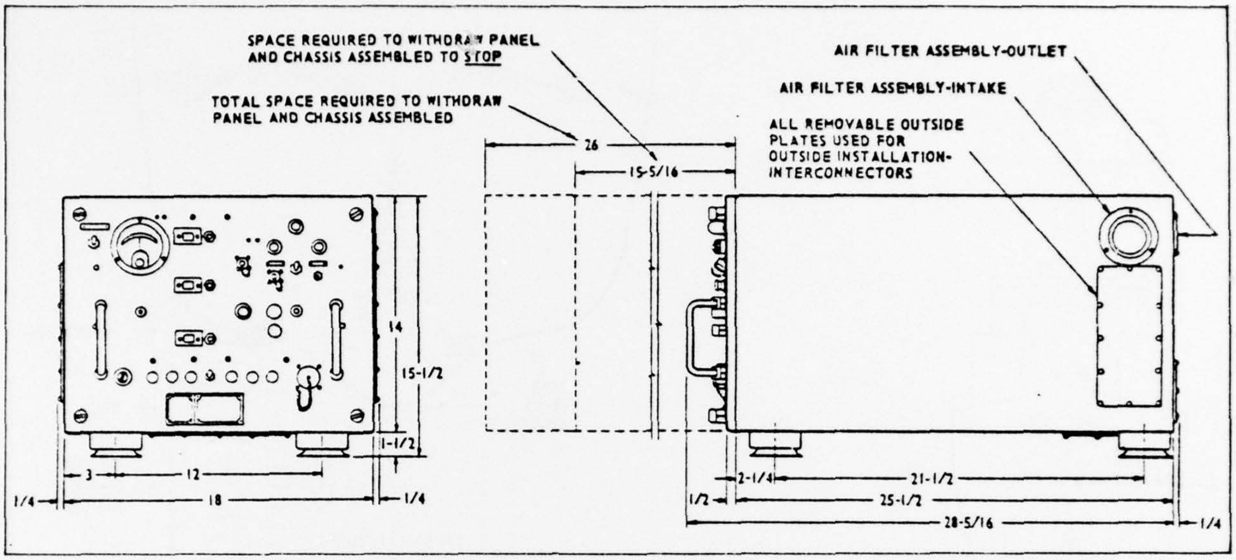


Figure C-5. Engineering Drawing. The representation of an object by means of lines, stressing precision of dimensions.

79236-15

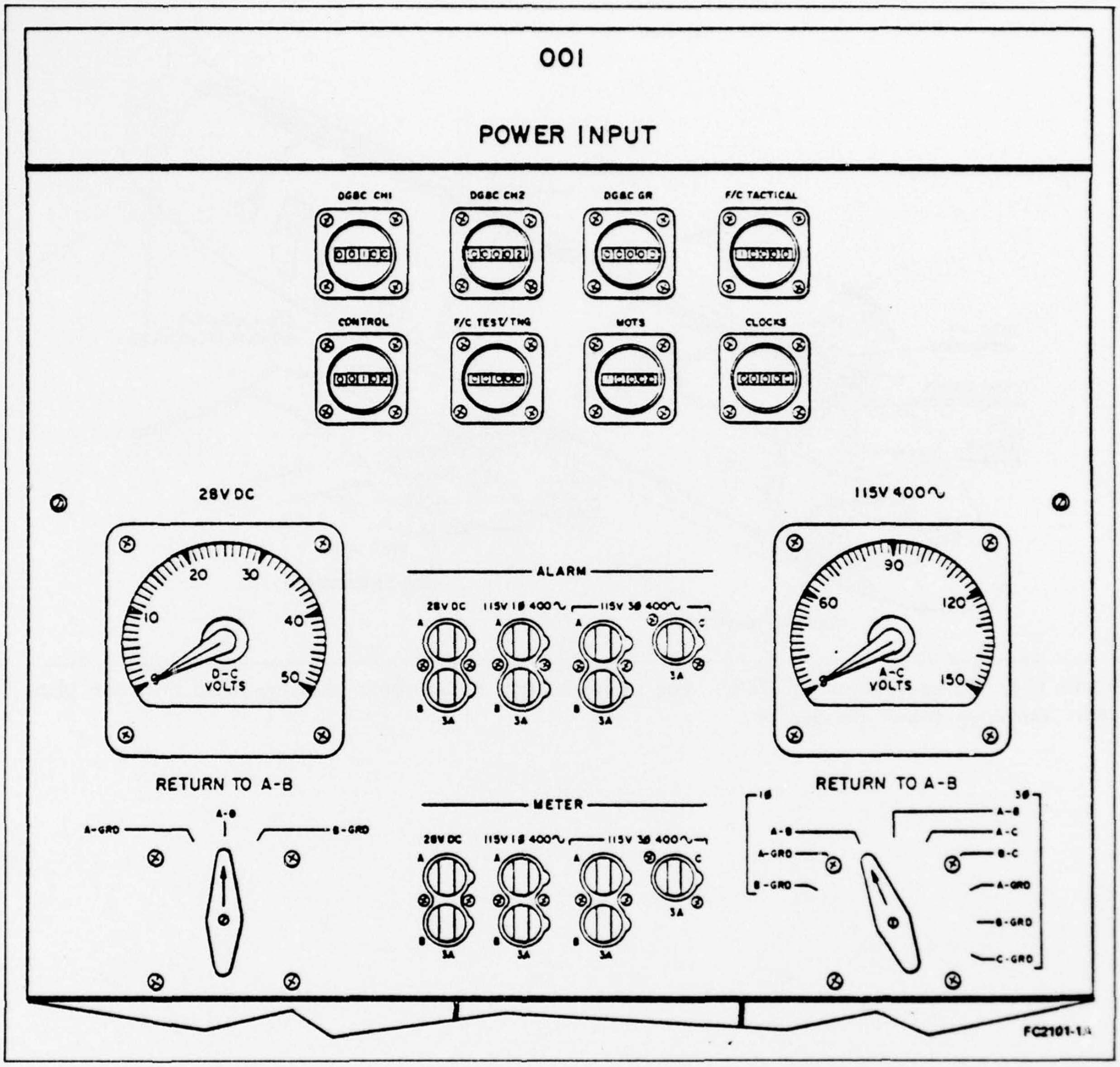


Figure C-6. Two-Dimensional View. The representation of an object in one plane, e.g., a front view without perspective/depth cues.

BEST AVAILABLE COPY

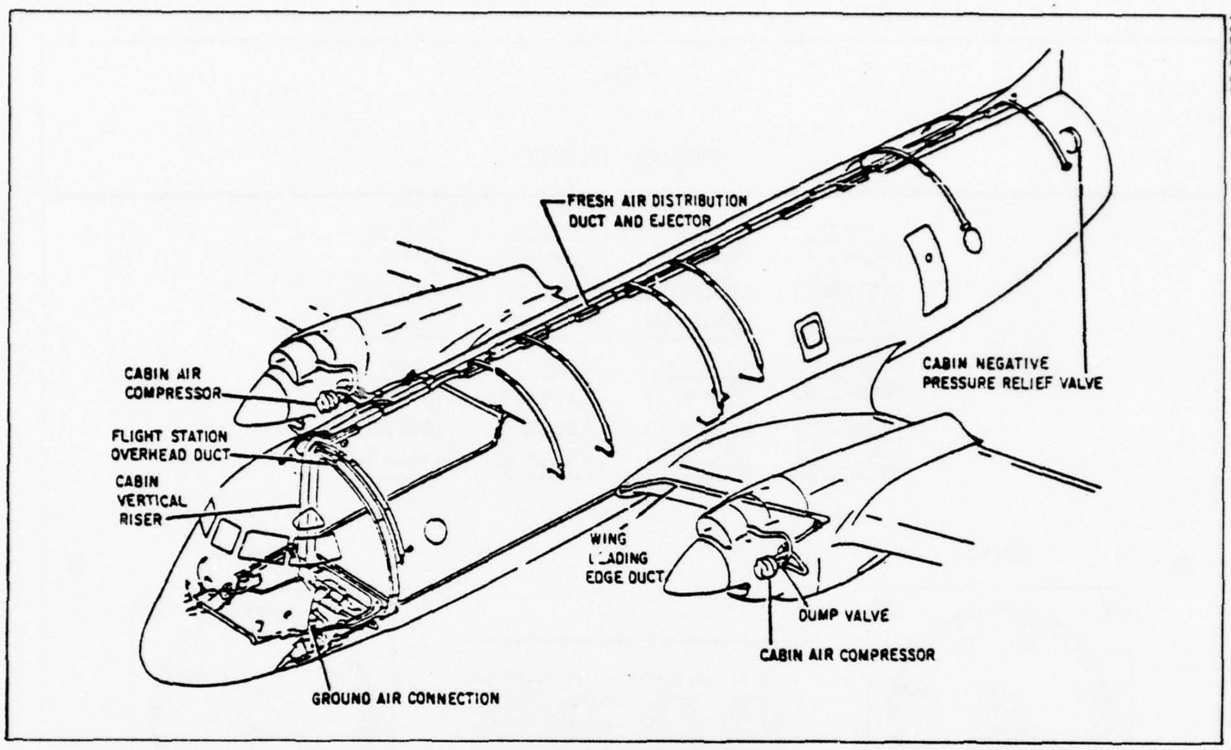
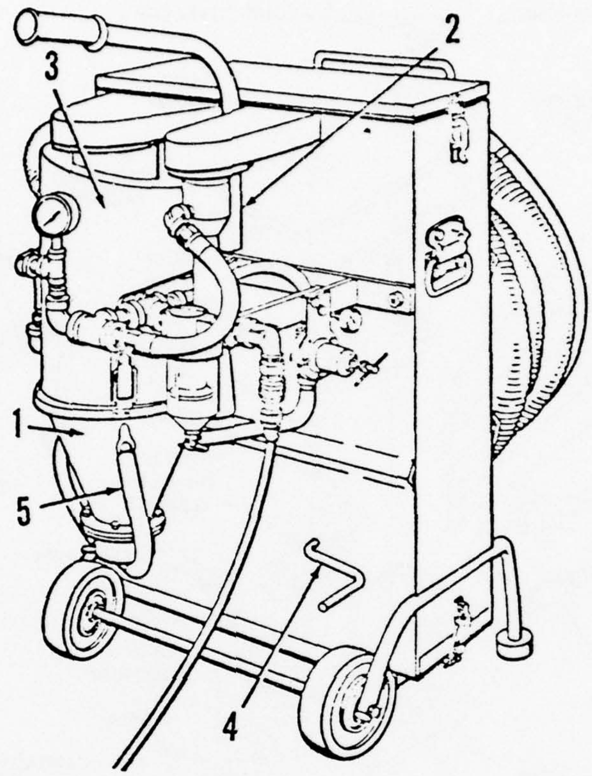


Figure C-7. Three-Dimensional View. The representation of an object showing more than one plane with "vanishing point" perspective.

79236-17



AM.912

1. Abrasive storage tank.
2. Air ejector pump.
3. Abrasive reclaimer.
4. Filter bag shaking handie.
5. Suction bypass line.

Figure C-8. Assembled View. A representation showing all parts of an object fitted together as seen in normal use.

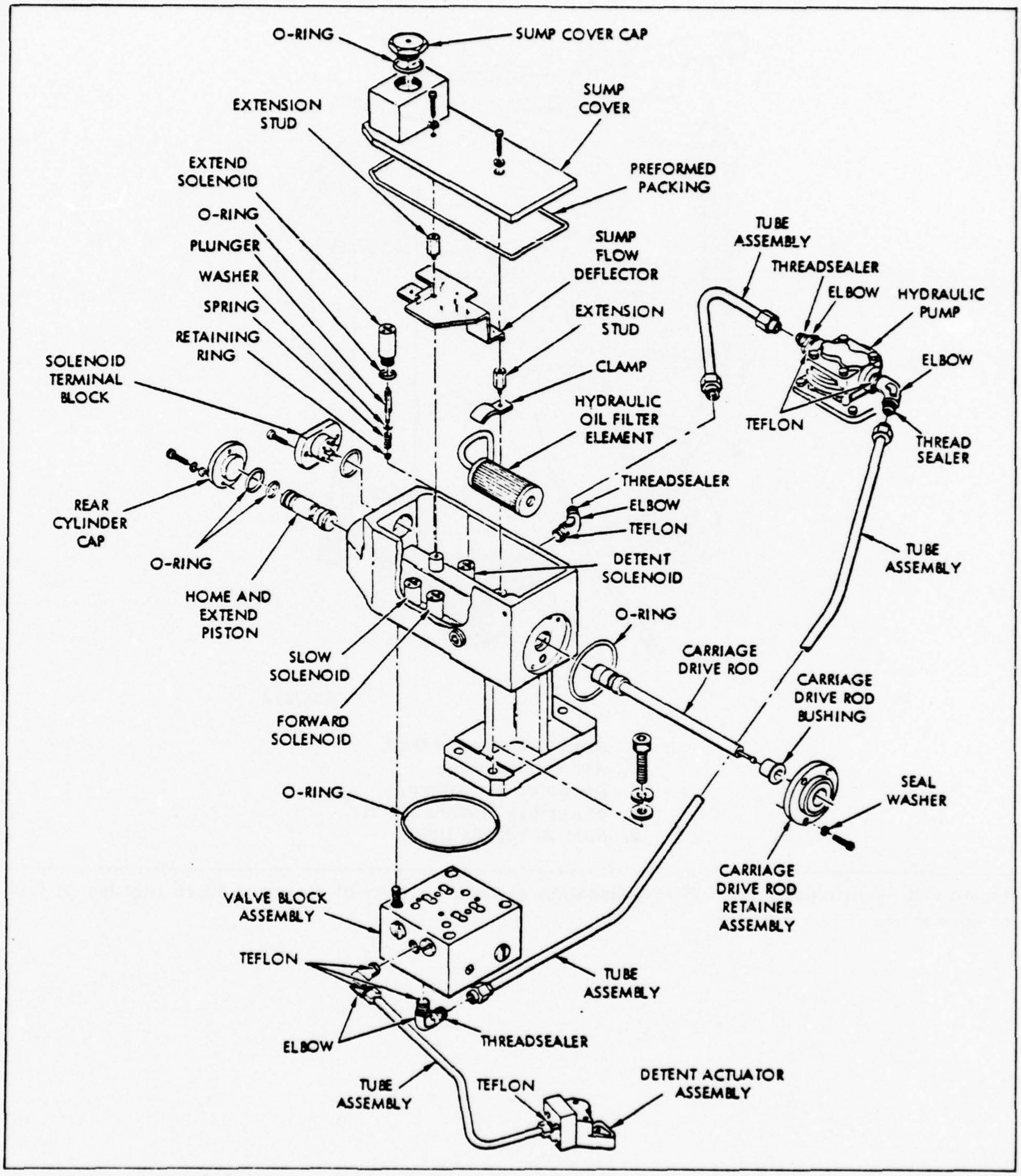


Figure C-9. Exploded View. A view of an object showing the parts separated, but in correct relationship to each other.

BEST AVAILABLE COPY

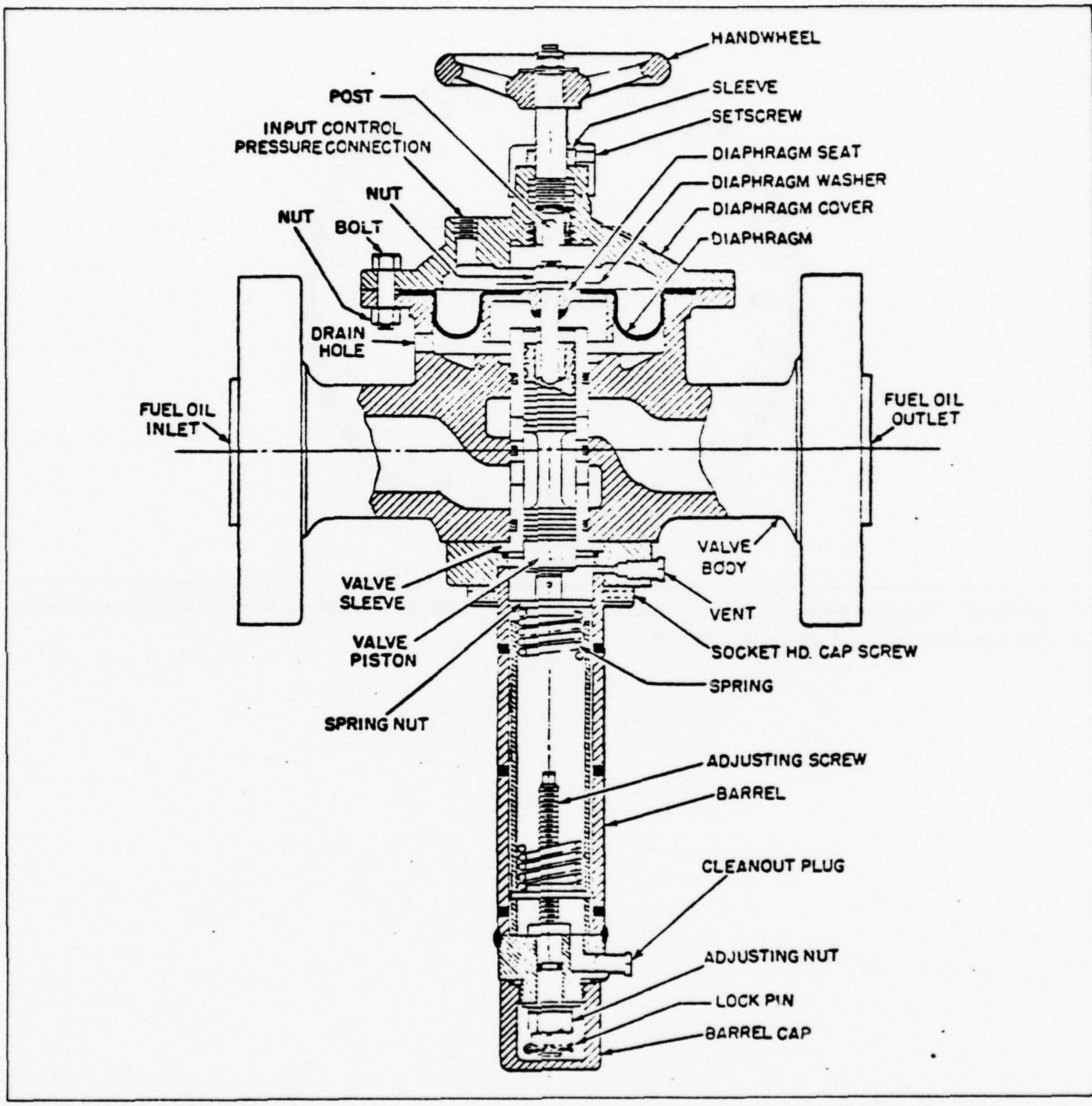


Figure C-10. Cut-Away View. A view showing exterior parts cut away to clarify the relationship and workings of inner parts.

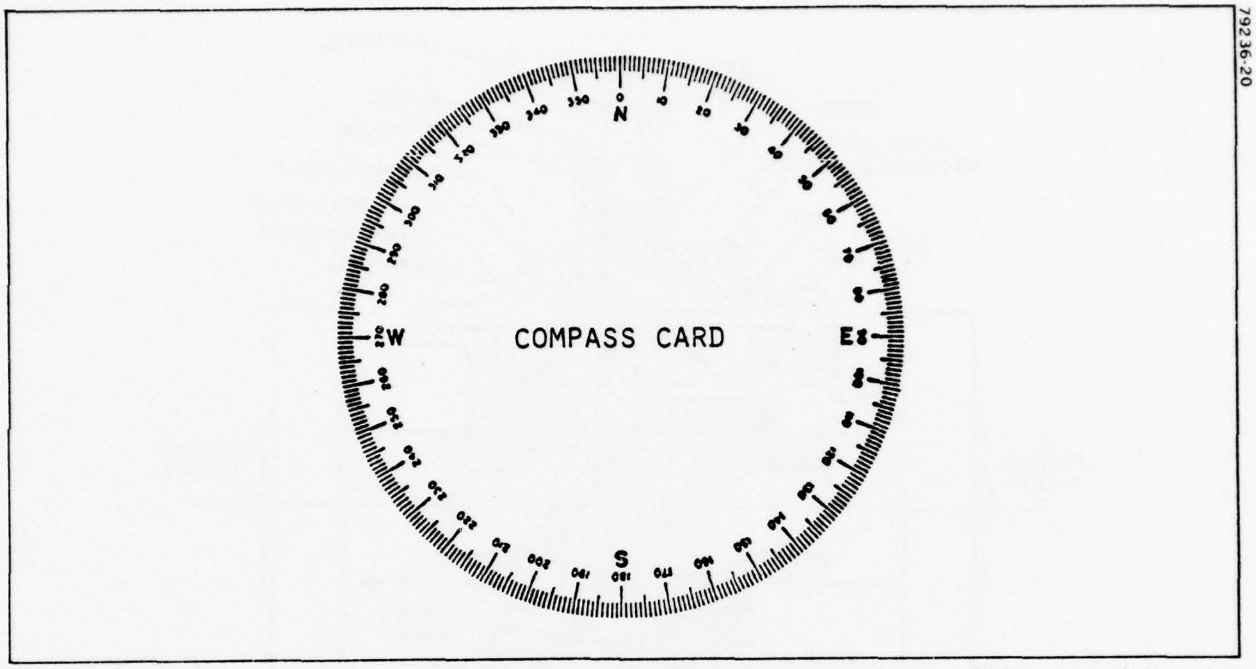
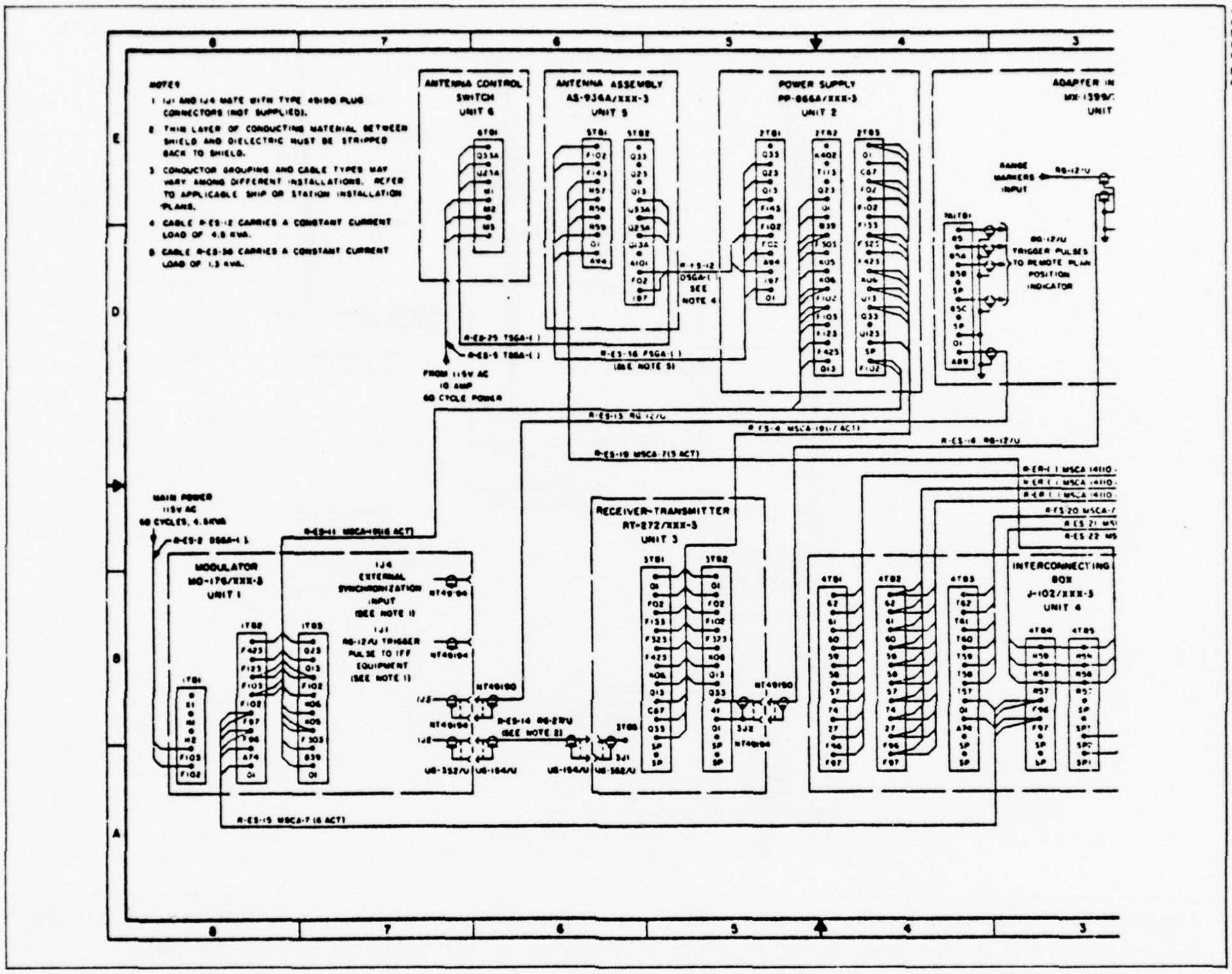


Figure C-11. Superimposed Locator. Where an identifier such as a word or symbol is printed directly on the representation of an object or part.



79236-21

Figure C-12. Coordinate Locator. Where an object or part is located or identified by reference to the point where two lines intersect at right angles. The lines are keyed to combinations of numbers and/or alphabetical characters.

BEST AVAILABLE COPY

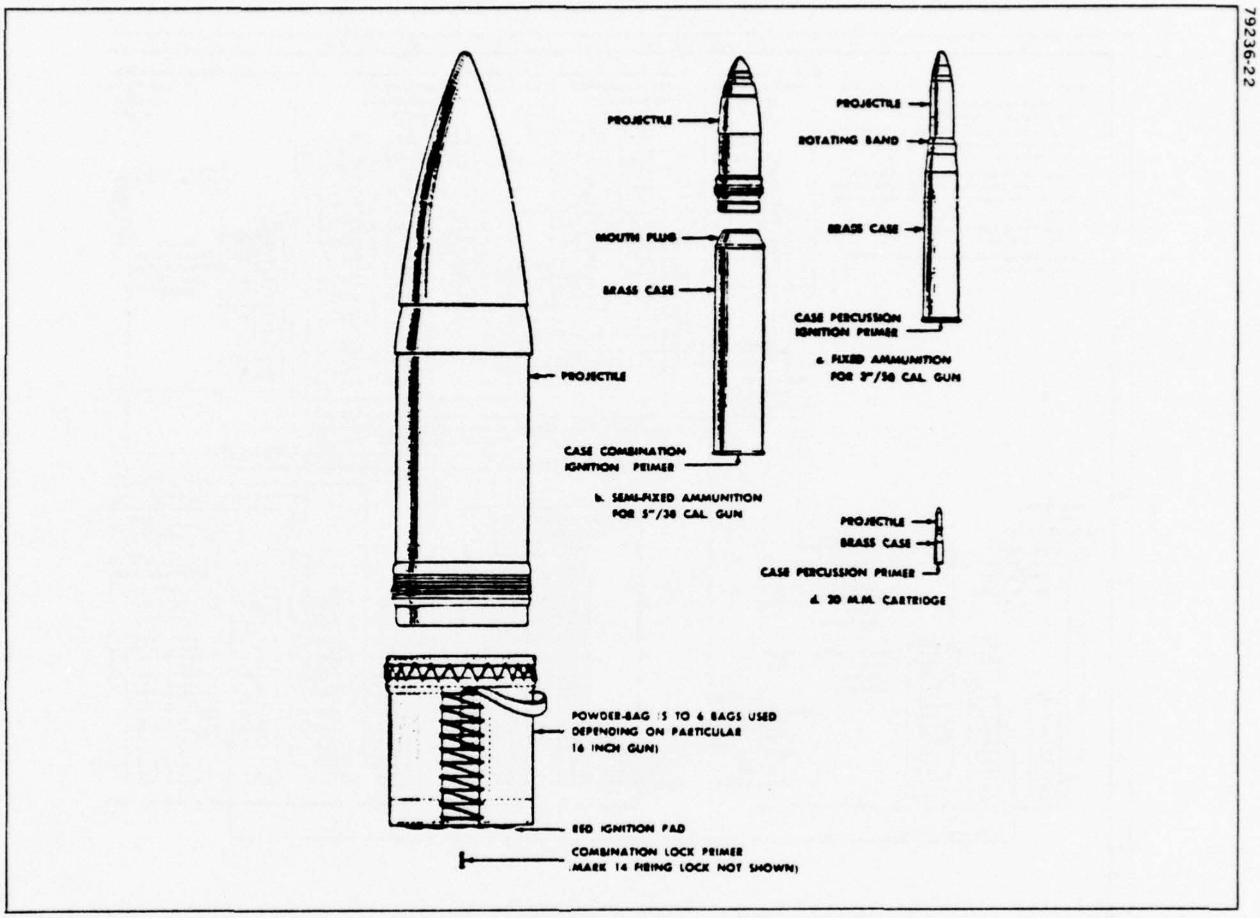


Figure C-13. Line and Leader Locator. Where a system of lines and arrows point toward an object or part, with the name, description, or other information at the opposite end of the line.

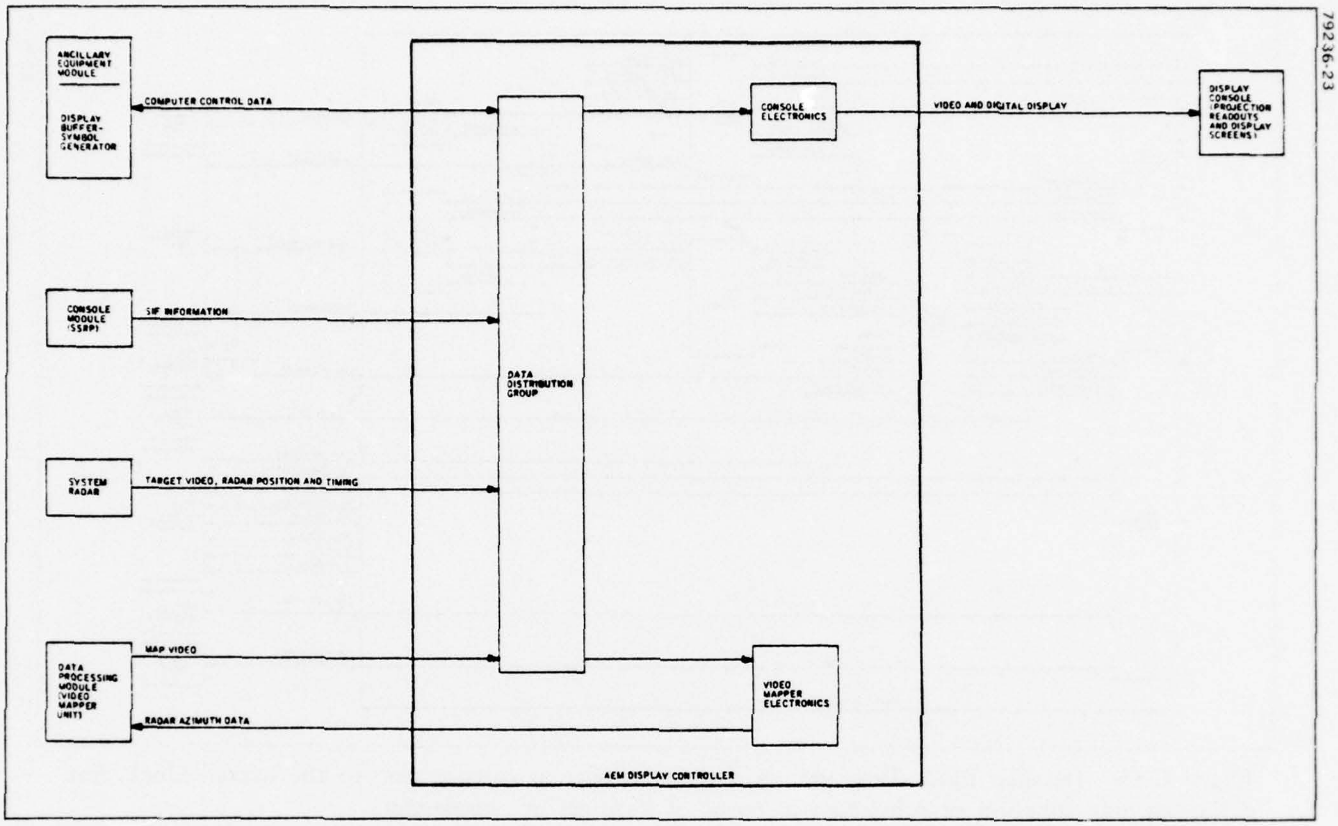
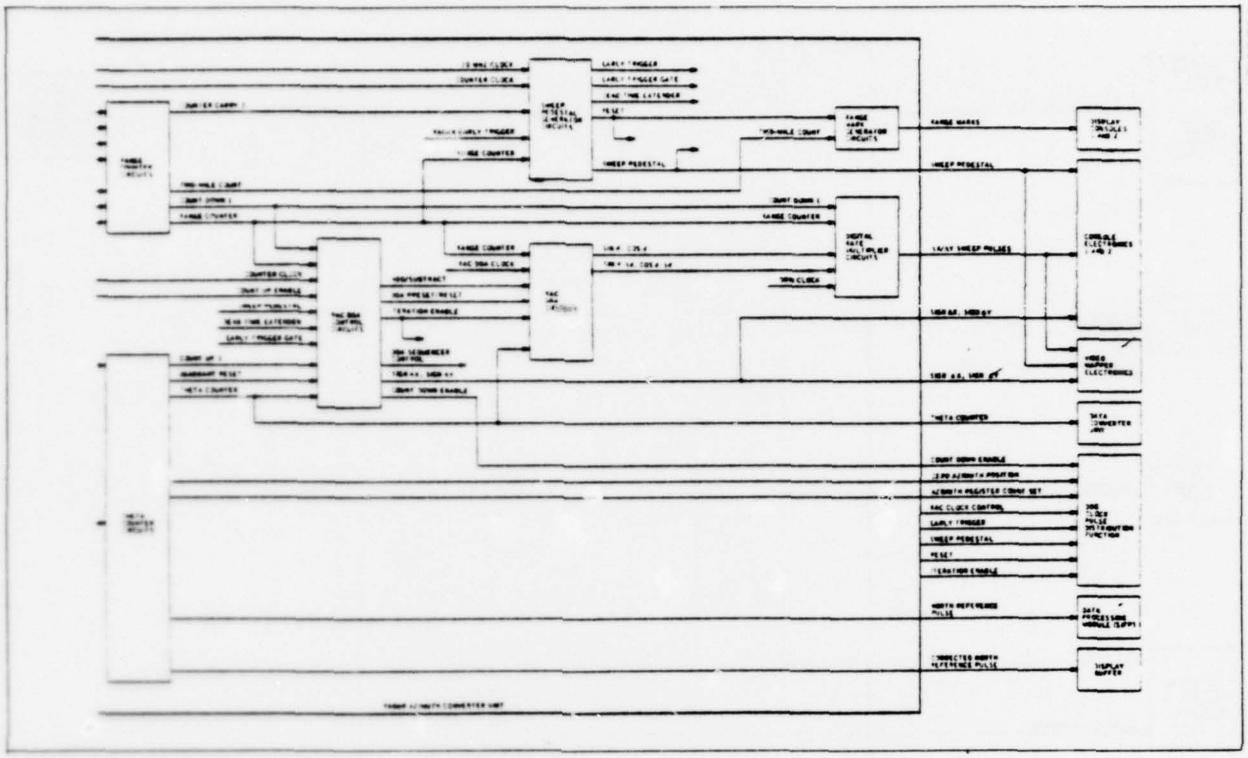


Figure C-14. Overall Block Diagram. A diagram composed of rectangular blocks connected by lines representing a physical and/or functional interface between components of a system.



79236-24

Figure C-15. Detailed Block Diagram. A diagram similar in construction to the overall block, but describing one function or subsystem in terms of its units or components.

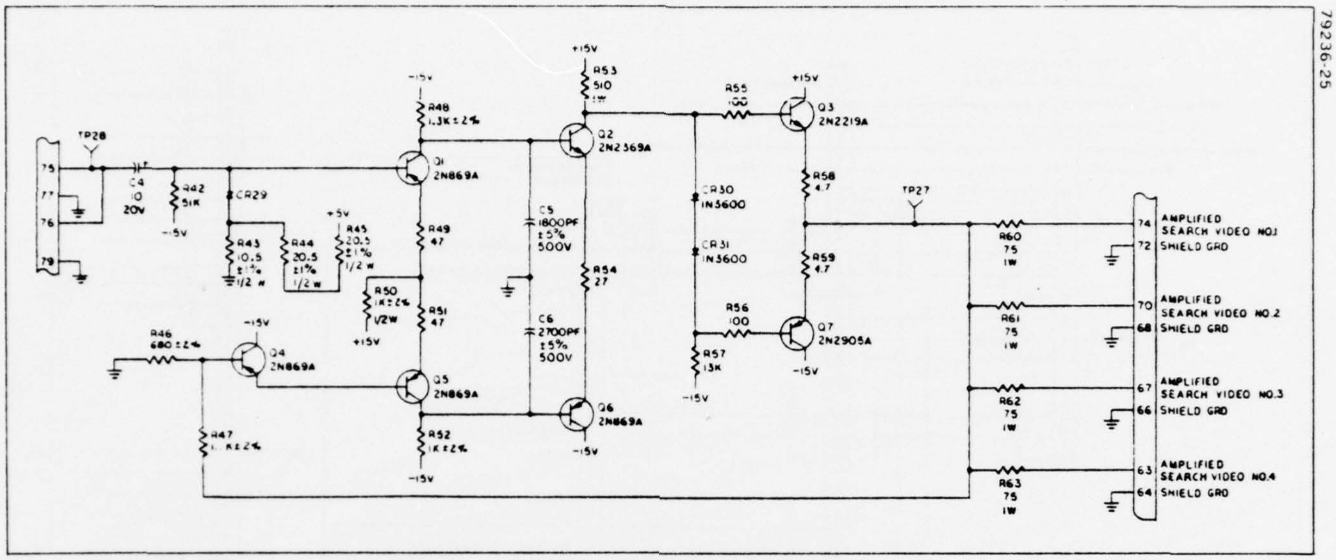
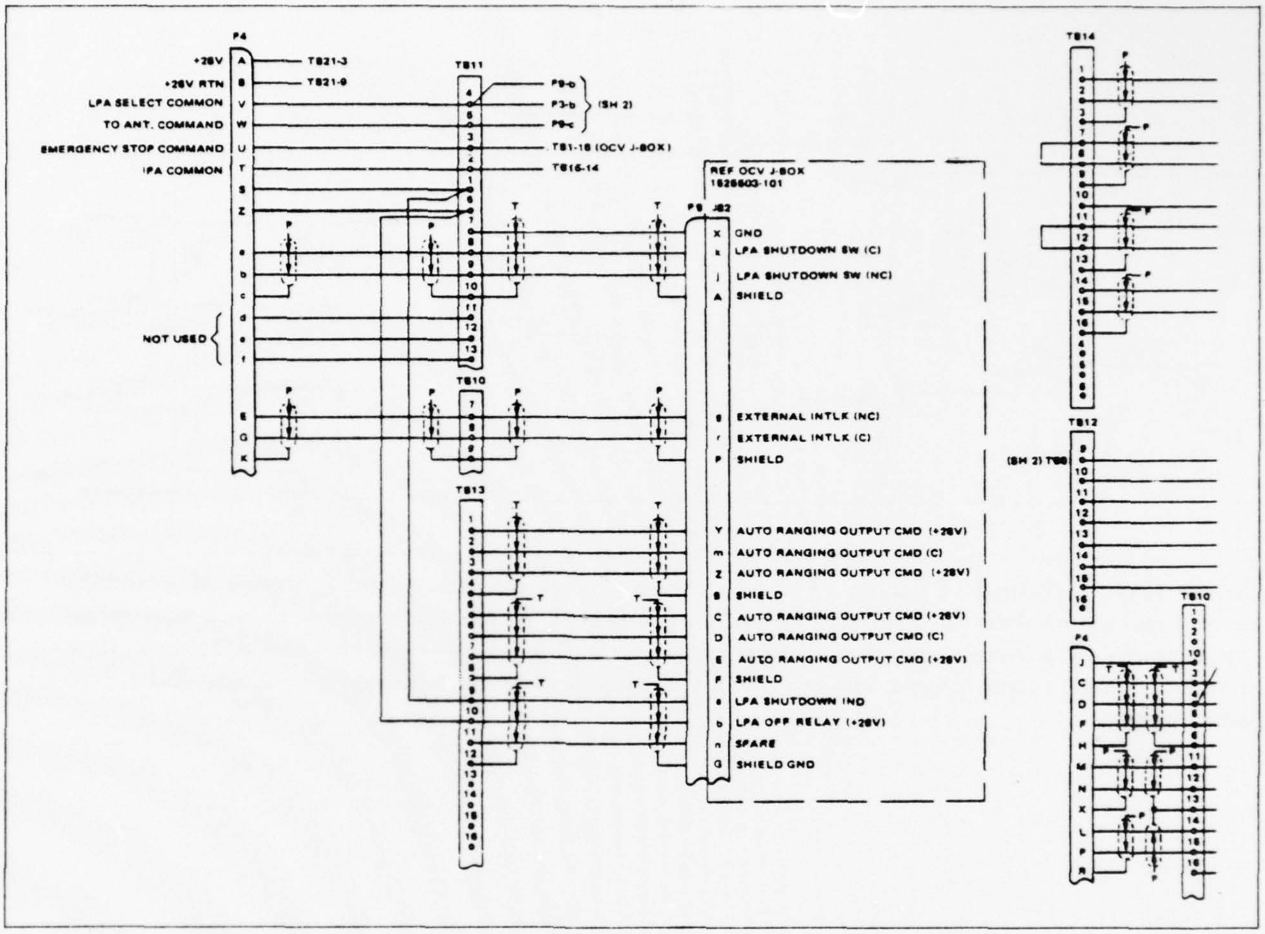
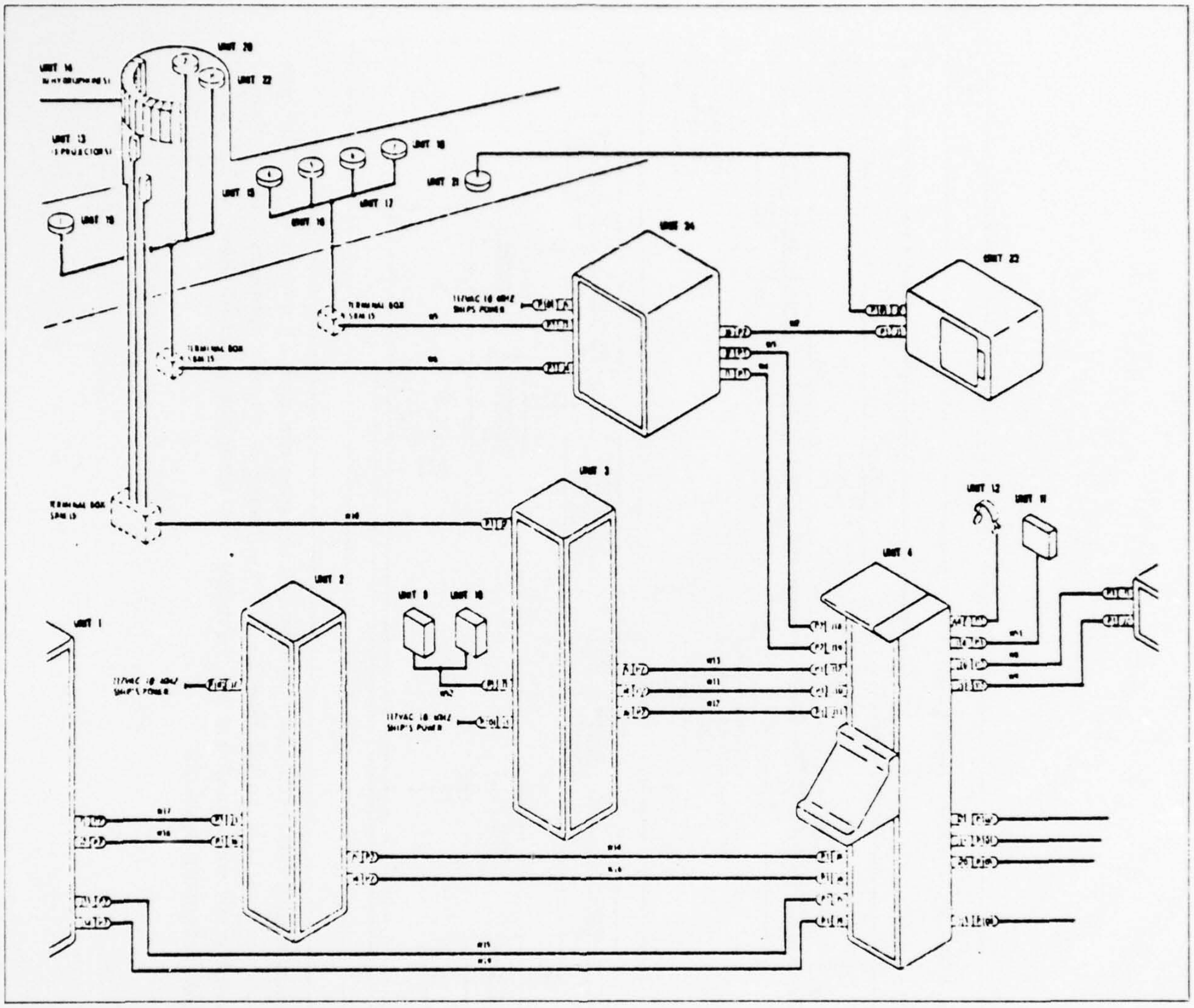


Figure C-16. Schematic Diagram. A diagram showing the connections and functions of assemblies and parts via symbols to illustrate the path of energy: electrical schematics show a conceptual arrangement of a circuit and components; piping schematics show hydraulic and pneumatic flow through pumps, valves, gauges, etc.; mechanical schematics show arrangements of gears, shafts, levers, and linkages.



79236-26

Figure C-17. Wiring Diagram. A diagram identifying the physical path of all electrical power and signals in a specified level of equipment. Individual wires may be coded alphanumerically with their connection points. The actual physical locations of the wires in a chassis are not necessarily pictorially represented in a wiring diagram.



79236-27

Figure C-18. Cabling Diagram. A diagram identifying individual cables by alphanumeric code. Coded connection points between equipments and assemblies are shown. It may be schematic or pictorial; the latter shows physical location.

79236-28

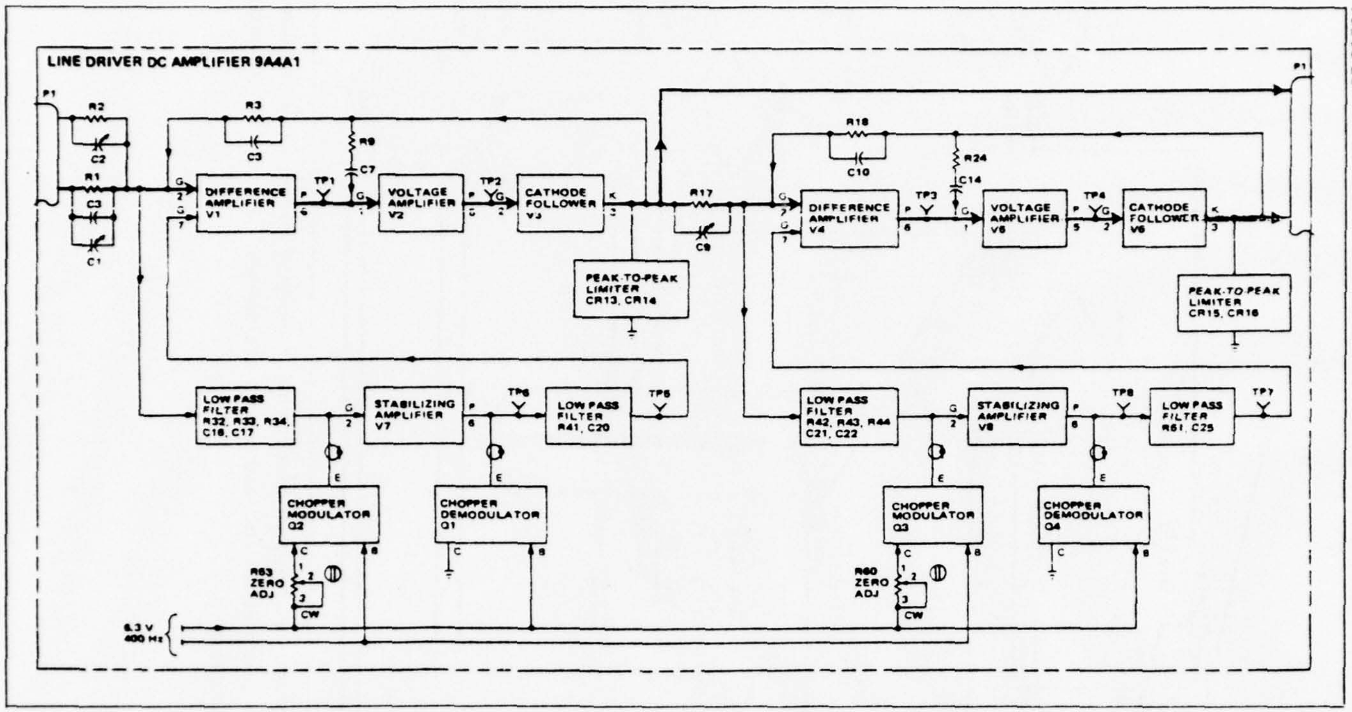


Figure C-19. Functional Signal Flow Diagram. A diagram showing the path of specific signals for one function. The diagram may include coded lines to aid in tracing a specific function and its basic groups of signals through a system, equipment, or assembly. It identifies point-to-point wiring and may have blocks and/or schematic symbols.

BEST AVAILABLE COPY

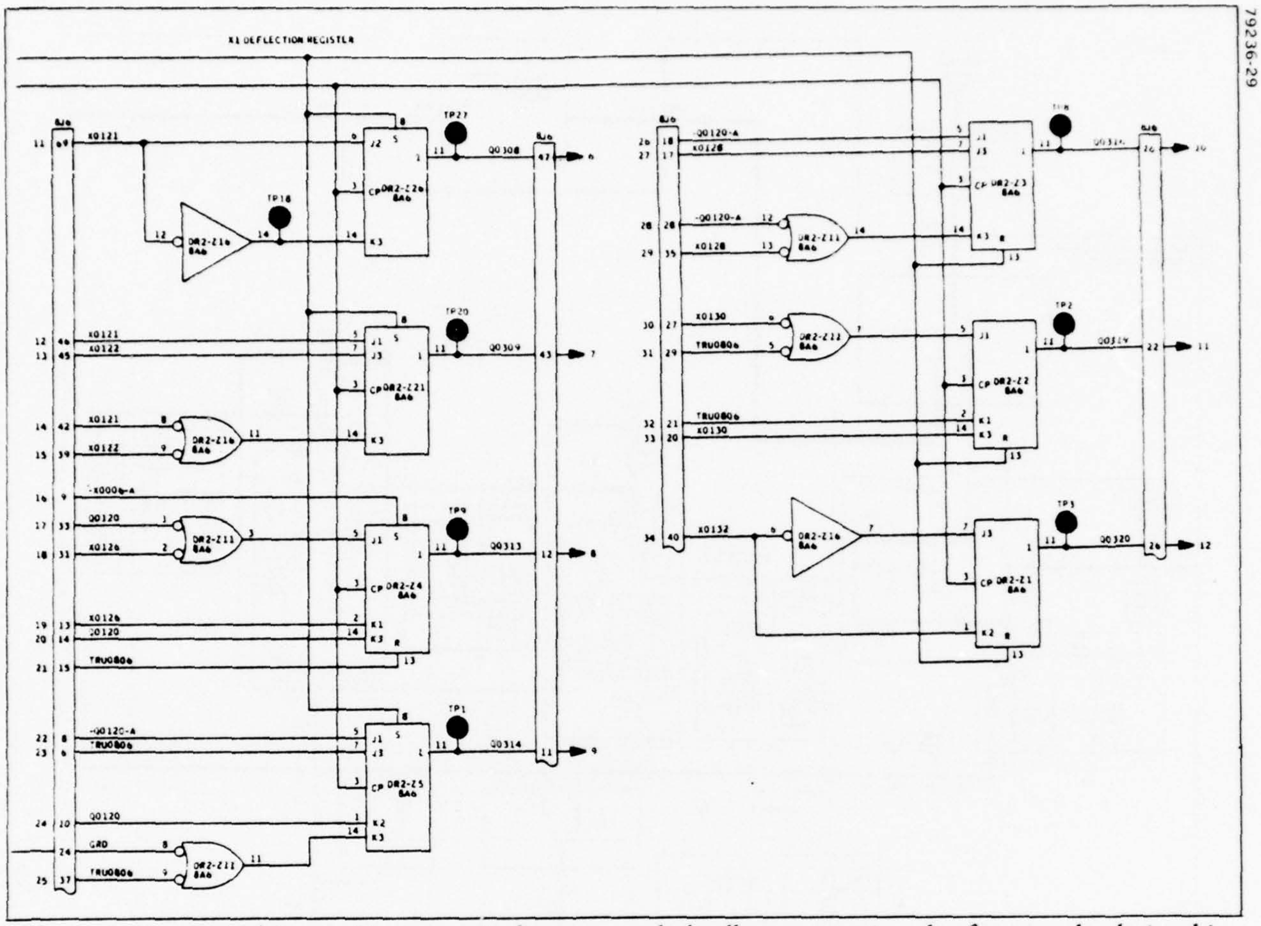
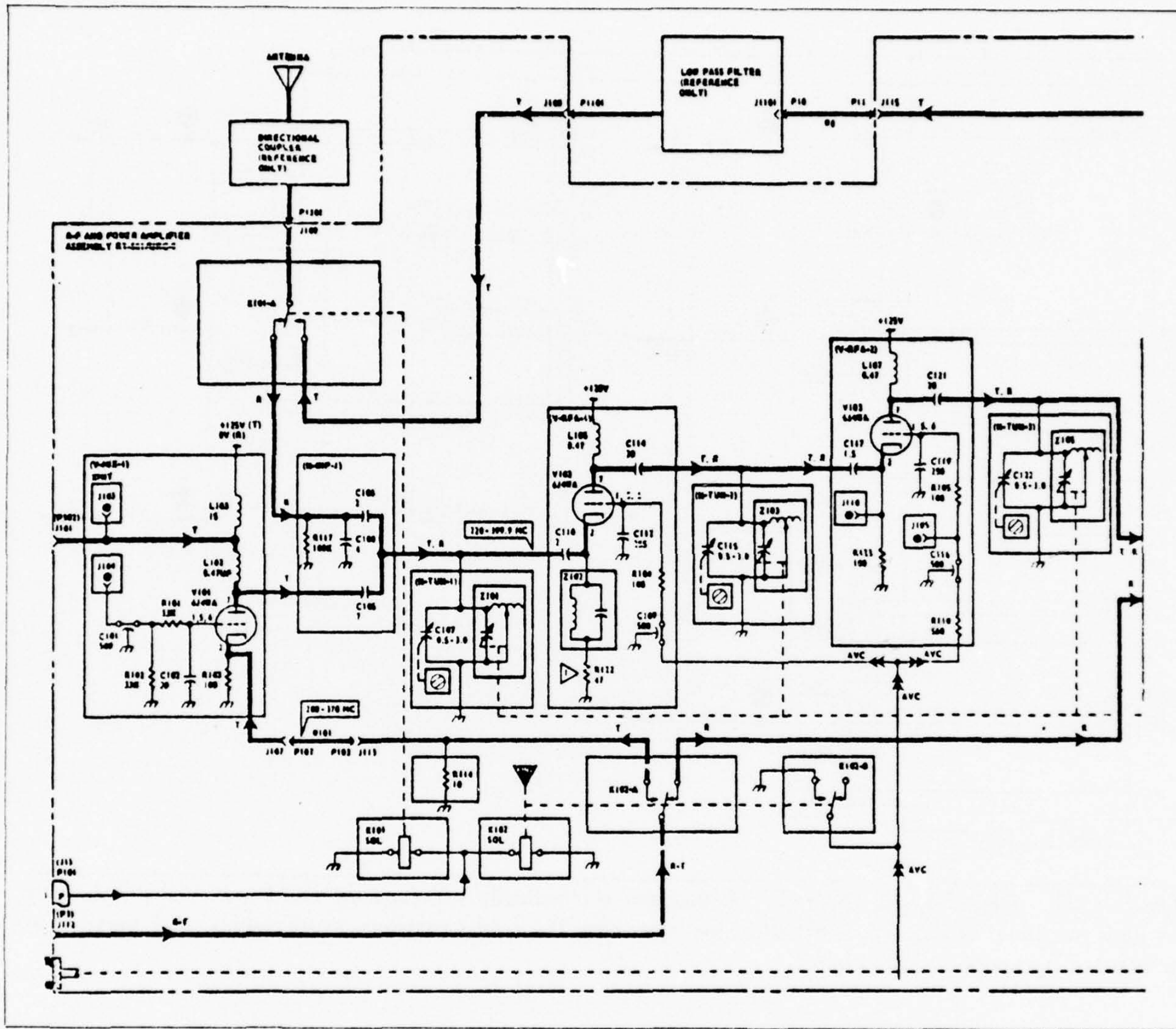


Figure C-20. Digital Logic Diagram. A diagram symbolically representing the functional relationship of logic sections, units, and assemblies, incorporating Boolean equations, truth tables, and signal characteristics, as necessary for clarity.

BEST AVAILABLE COPY



79236-30

Figure C-21. Blocked Schematic Diagram. An electrical, mechanical, or piping schematic diagram superimposed on a block diagram to show physical relationships and functional interfaces simultaneously.

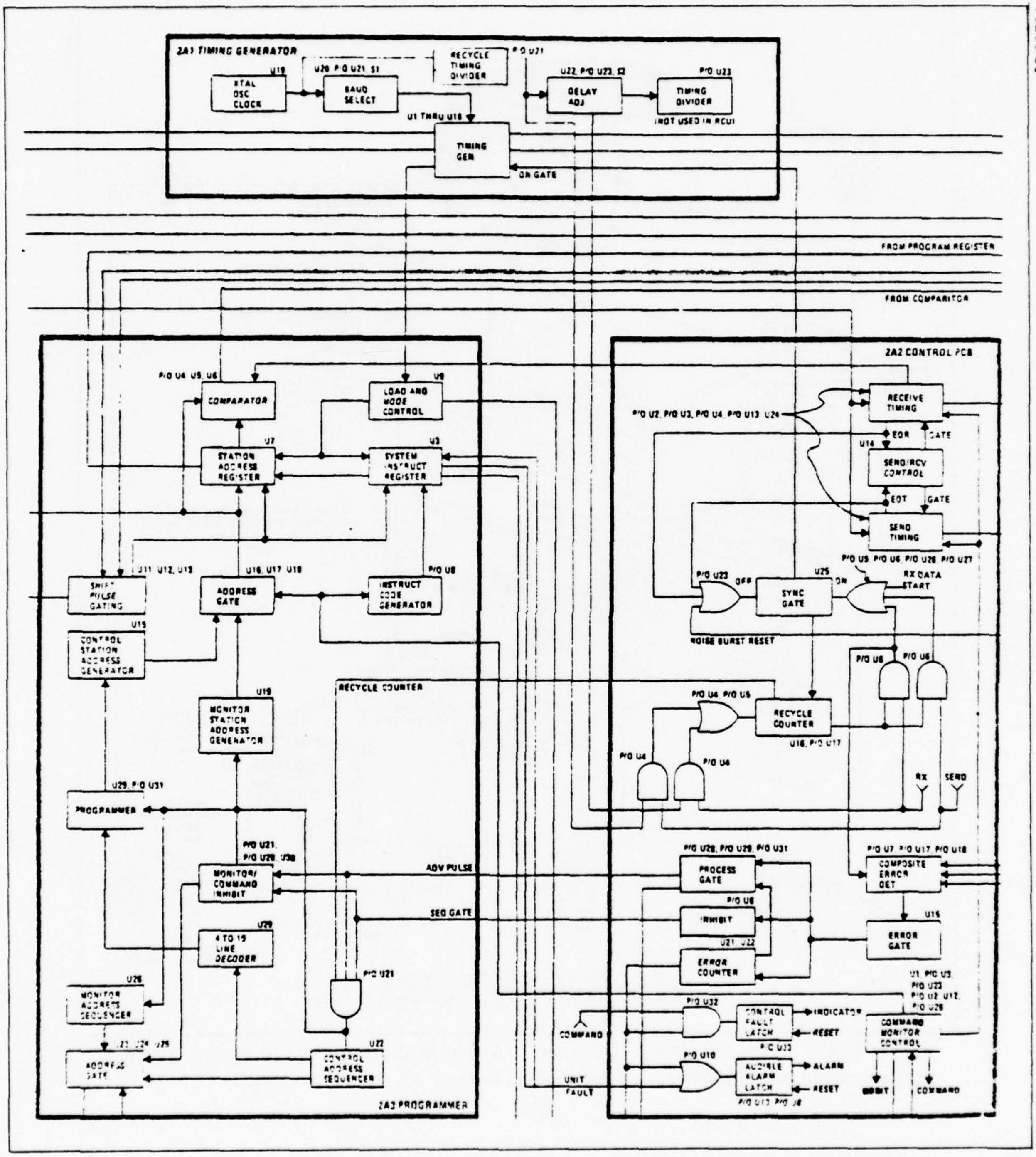


Figure C-22. Block Digital Logic Diagram. Digital logic symbology superimposed on block diagrams to represent two levels of complexity simultaneously.

79236-31

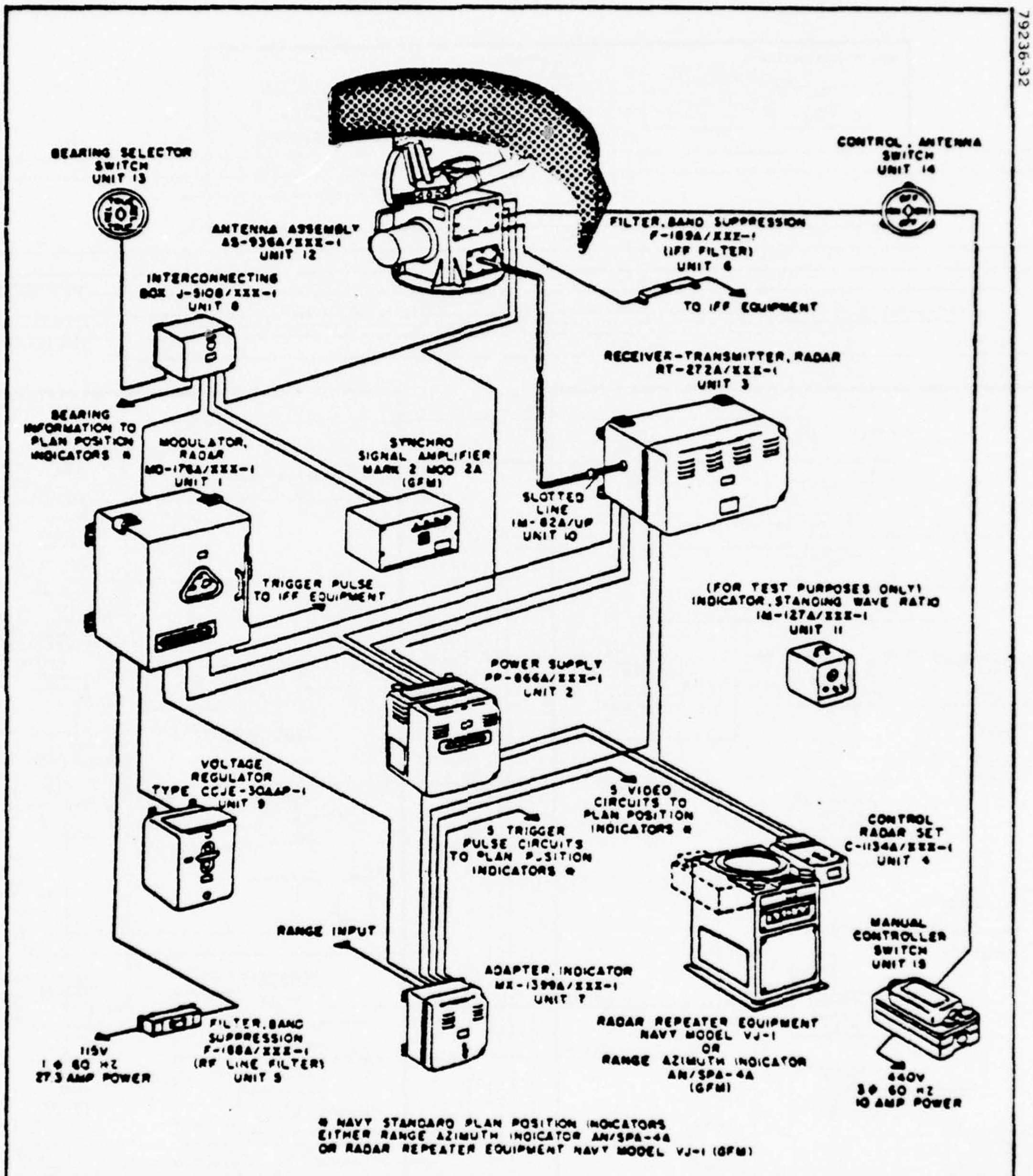


Figure C-23. Pictorial Block Diagram. A block diagram incorporating pictorial representation of equipment or assemblies instead of simple rectangles.

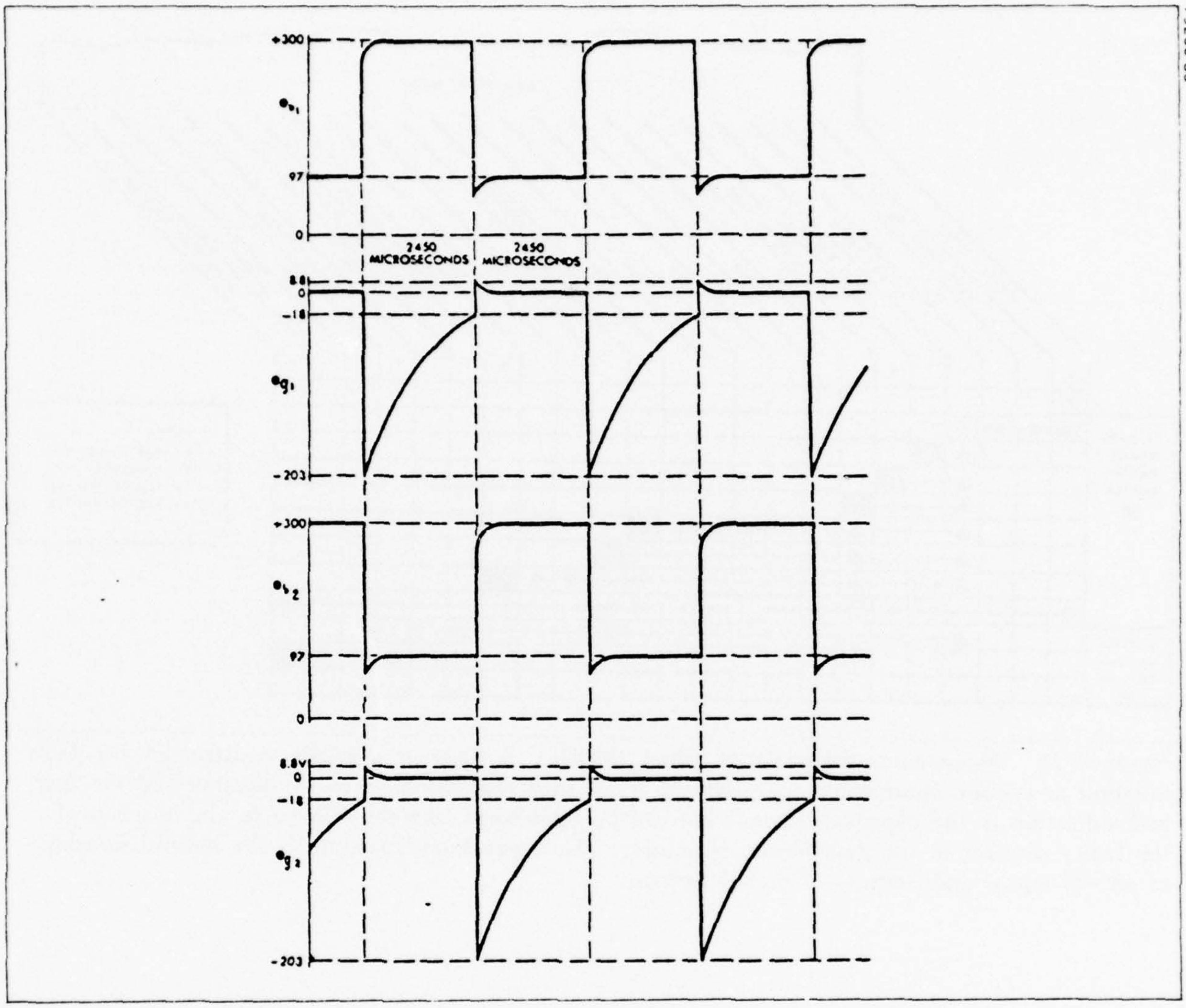
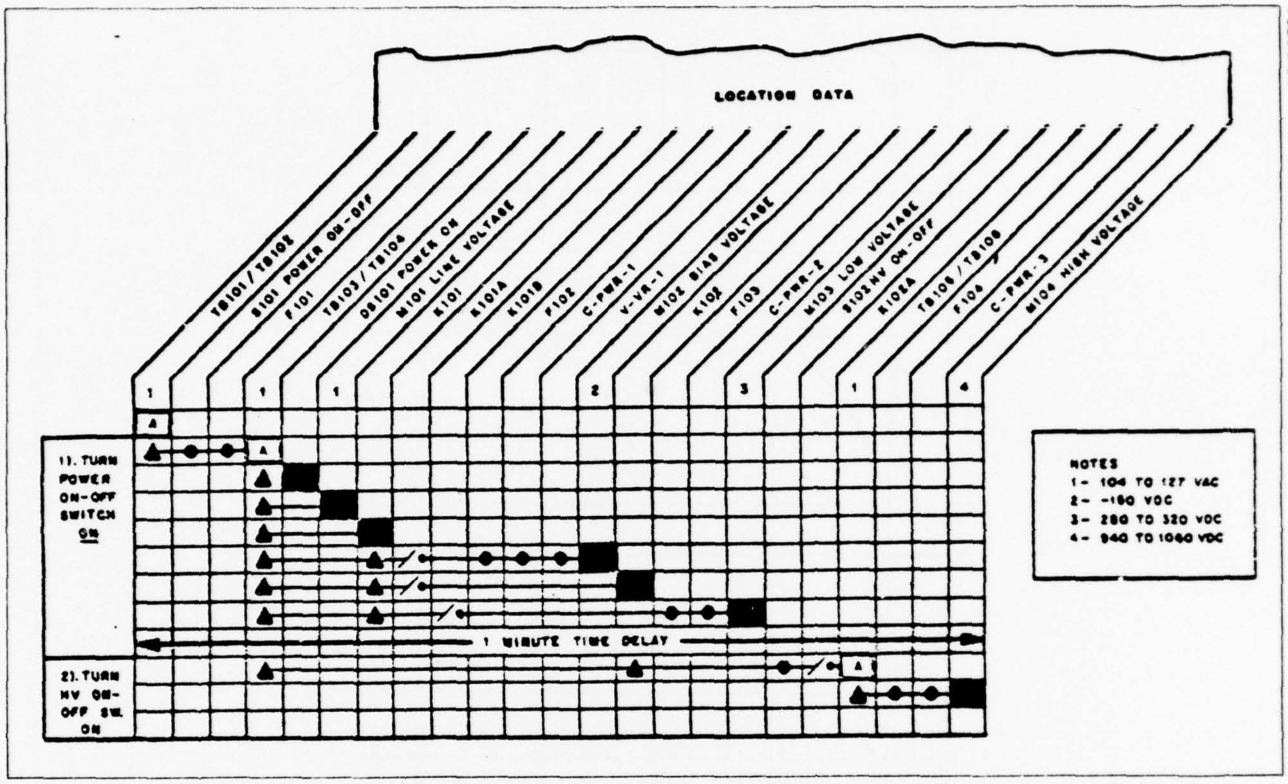


Figure C-24. Timing Diagram. A diagram showing the relationships among a group of timing signals by their alignment against a common origin on a graphic time scale.



79236-34

Figure C-25. Maintenance Dependency Chart (MDC). A diagram specially constructed for fault isolation at system, equipment, and assembly levels such that the last good indication and the first bad indication in the dependency structure can be established, thereby leading to the location of the faulty element in the dependency structure. The dependency structure is the interrelationship of all the inputs and outputs of each function.

79236-35

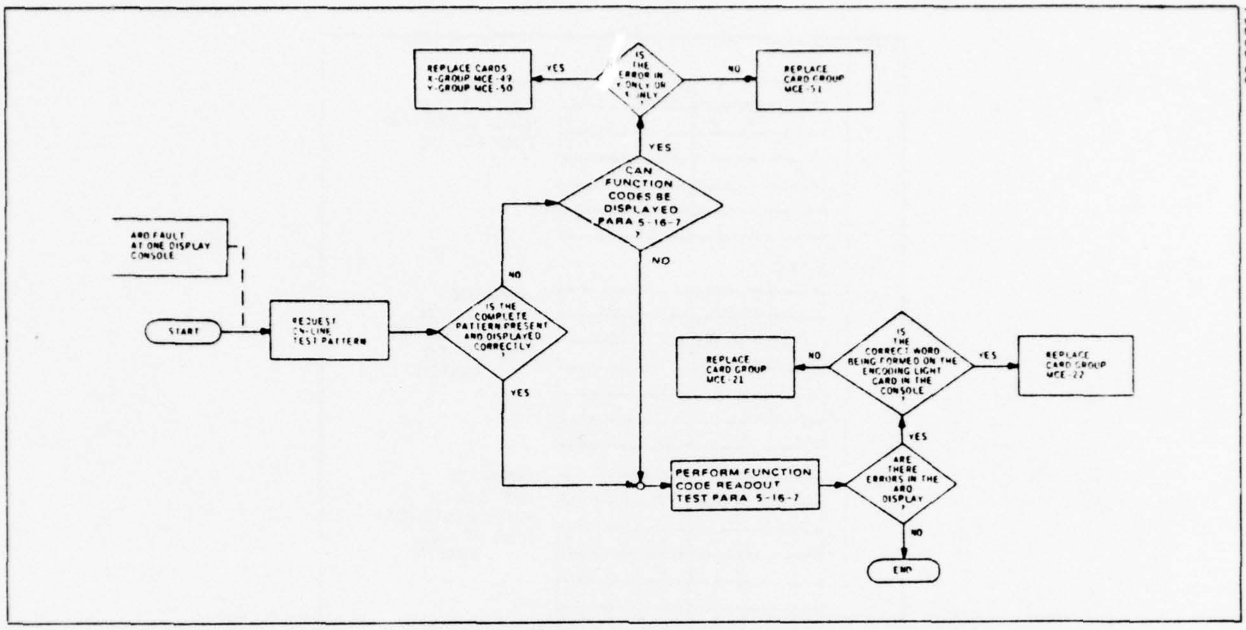


Figure C-26. Decision Tree. A diagram incorporating symbols for actions and indications as part of a forced sequence of actions to be followed when operating or troubleshooting equipment. Each *indication* has a *binary output* (*yes – no*; *good – bad*; *etc.*) forcing the choice of the next appropriate indication or action.

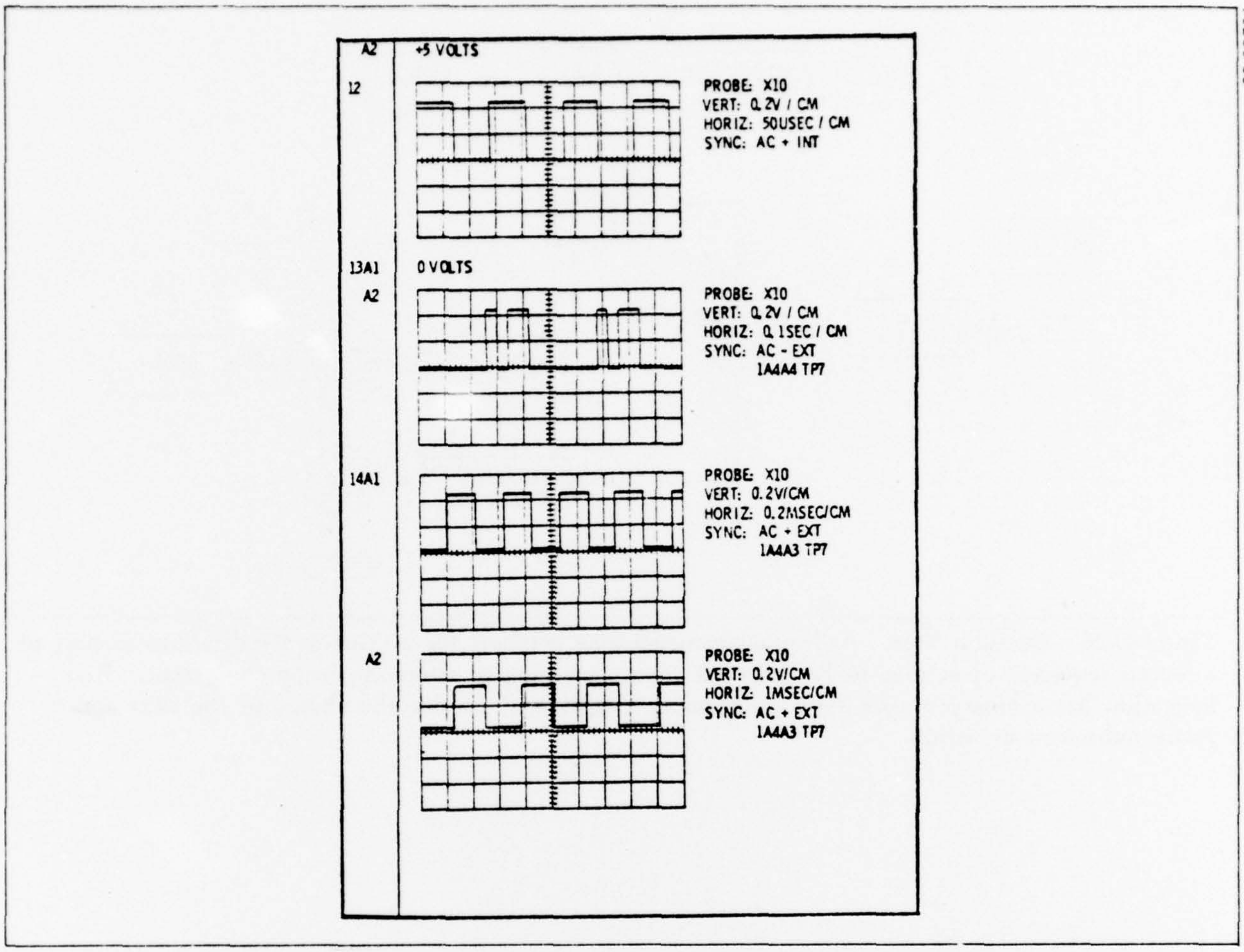


Figure C-27. Waveform. A graphical representation of the shape of an electrical wave that indicates the characteristics of frequency and amplitude on a scale.

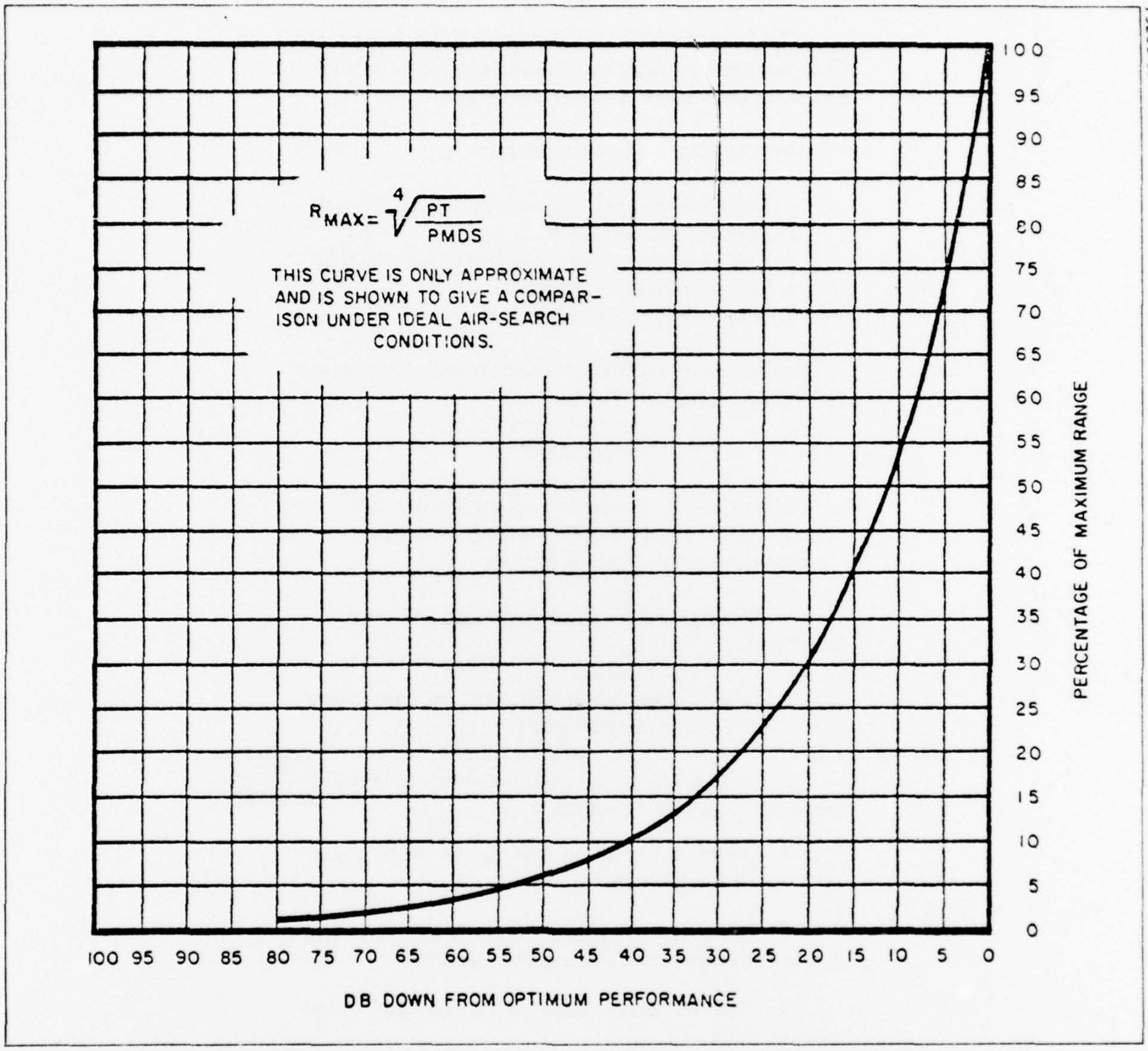


Figure C-28. Graph. A diagram that illustrates a set of data plotted against one or more scales. The diagram expresses the relationship between two variables.

2.7.8.2 **Sector Pulse Block Assembly Replacement.** This paragraph contains the replacement procedures for the sector pulse block assembly, figure 2-47.

The following tools are required:

1. Nut driver or open end wrench, 1/4- or 3/8-inch
2. Allen wrench, 3/64-inch
3. Cam disconnect tool, NAVORD Dwg 3902288
4. Phillips screwdriver, number 2
5. Loctite, MIL-S-22473, Grade C

Replace sector pulse block assembly and sector pulse pivot helical spring as follows:

WARNING

Position all circuit breakers on appropriate disk drive PCP panel to OFF. Failure to remove power can result in personal injury.

1. Remove sector pulse and support assembly (chapter 2).

2. Using a cam disconnect tool, remove spring anchor and helical extension spring.

3. Remove 1/4- or 3/8-inch nut from sector pulse and support assembly pivot pin.

4. Loosen Allen screws that secure pivot pin to sector pulse block assembly.

5. Remove sector pulse pivot pin and compression spring from sector pulse and support assembly.

6. Remove sector pulse block assembly from support block.

7. Remove stop nut and nylon setscrew from old sector pulse block assembly and install in new sector

79236-38

Figure C-29. Directive Text. A writing style in which sentences start with the imperative form of a verb, so the reader is commanded to perform an action.

79236-39

Troubles which may prevent a centrifugal blower from performing its function generally involve damage to the rotor shaft, thrust bearings, turbine blading, nozzle ring, or blower impeller. Damage to the rotor shaft and thrust bearings usually occurs as a result of insufficient lubrication, an unbalanced rotor, or operation with excessive exhaust temperature.

Centrifugal blower lubrication difficulties may be caused by failure of the oil pump to prime, low lube oil level, clogged oil passages or oil filter, or a defect in the relief valve which is designed to maintain proper lube oil pressure.

If an unbalanced rotor is the cause of shaft or bearing trouble, there will be excessive vibration. Unbalance may be caused by a damaged turbine wheel blading, or by a damaged blower impeller.

Turbine blading damage in a centrifugal type blower may be caused by operating with an excessive exhaust temperature, by operating at excessive speeds, by bearing failures, by failure to drain the turbine casing, or by the entrance of foreign bodies.

Nozzle ring damage may be caused by excessive exhaust gas temperature, foreign bodies, and turbine blades which break loose.

Figure C-30. Deductive Text. A writing style in which facts relating to the operation or maintenance of equipment are presented as premises requiring the reader to bridge the gap between supplied information and unstated conclusions.

4-100. MV/HV POWER SUPPLY.

4-101. GENERAL. The MV/HV power supply (T.O. 31S1-2TSQ91-63, fig 6) provides +15-kv and +500v power for the ppi and ARO crt. The +15-kv accelerating potential is supplied directly to both ppi and ARO crt. The +500v is supplied to the ppi and ARO intensity amplifiers to provide voltage for the cathode, accelerating electrode, and focusing anode of both ppi and ARO crt. The MV/HV power supply consists of timing circuits, power supply circuits, and regulator-sensor circuits.

4-102. The timing circuits contain a timing pulse generator that produces a timing pulse to control a HV switch-driver in the power supply circuits; a +15-kv error amplifier that produces an amplified error signal to control the duty cycle of the timing pulse from the timing pulse generator; a +500v overcurrent or ±15v fault protection circuit that disables the timing pulse generator when either an overcurrent condition occurs in the +500v power supply or a fault occurs in the -15v input power source.

79236-40

Figure C-31. Continuous Text. Text written in a normal prose style; a smooth narrative divided appropriately into paragraphs.

79236-41

1A4A3 4-AN/UQN-4 REFERENCE ASSEMBLY

GENERATES A 144KHZ REFERENCE FREQUENCY FOR OVERALL SYSTEM TIMING. CONTAINS COUNTER / DIVIDERS TO DIVIDE THE 144KHZ TIME BASE SIGNAL INTO THE VARIOUS TIMING FREQUENCIES REQUIRED.

PROVIDES KEEL REFERENCE CORRECTION SO BOTH RECORDER AND DIGITAL READOUT READ DEPTH BELOW THE KEEL RATHER THAN FROM BELOW THE TRANSDUCER. THIS IS ACCOMPLISHED BY ADVANCING THE KEYING SO TRANSMIT PULSES CAN OCCUR PRIOR TO THE DISPLAY ZERO DEPTH TIME.

PROVIDES LAMP DRIVE FOR FEET / FATHOMS INDICATORS, FLASHING ELEK KEYING INDICATOR LAMP, AND DSCRM MODE LAMP WHICH AUTOMATICALLY FLASHES IN WATER LESS THAN 30 FEET.

PRODUCES A GATING SIGNAL AND A GATE TO PREVENT THE RECOGNITION OF A FALSE ECHO AND SOME TRANSMIT REVERBERATION BY THE DISPLAYS. A GATE IS INCLUDED TO ELIMINATE THE CHART TRANSMIT TIME ZERO MARK IN 600 FEET AND FATHOM SHORT PULSE RANGES. IT INCLUDES MEANS TO CHECK AND ADJUST CHART ZERO.

PROVIDES ELECTRONIC KEY PULSES FOR ELECTRONIC KEYING AND DISABLES THE RECORDER DRIVE WHEN ELECTRONIC KEYING MODE IS SELECTED. PROVIDES CIRCUIT TO DISABLE RANGE GATE WHEN IN SINGLE PING OPERATION.

1 C-PWR-1

FILTERS AND DISTRIBUTES +5 VOLT POWER.

2 TRACKING PULSE DISABLE GATE

I-INV-1 INPUT IS LOW IN AUTO, ALLOWING OUTPUT TO BE TRACKING PULSE NO. 2. WHEN THE AUTO PING SIGNAL IS HIGH, OUTPUT IS LOW, SHORTING OUT THE TRACKING PULSE TO DISABLE THE RANGE GATE IN SINGLE PING.

3 144KHZ OSCILLATOR

CRYSTAL CONTROLLED TRANSISTOR OSCILLATOR PROVIDES A 144KHZ REFERENCE FREQUENCY FOR ALL TIMING CIRCUITS IN THE AN/UQN-4.

4 ÷2 COUNTER NO. 1

I-FF-1 IS TOGGLED BY NEGATIVE GOING EDGE OF Q-OSC-1 OUTPUT. I-FF-1 OUTPUT IS A 72KHZ SQUARE WAVE WHICH IS USED AS A STARTING POINT FOR ALL SUBSEQUENTLY USED FREQUENCIES.

5 ADVANCE KEYING PULSE GENERATOR

I-BMV-1 GENERATES A POSITIVE 5USEC PULSE EACH TIME ONE OF THE ADVANCED KEYING PULSE INPUTS IS ALTERNATELY GROUNDED BY THE 1A6 KEYER. A29-E AND A29-F OPERATE TOGETHER AS A FLIP-FLOP THAT REMEMBERS WHICH INPUT WAS PREVIOUSLY GROUNDED. C8 OR C9 MOMENTARILY PASS THE GROUND CHANGE SENSED BY THE FLIP-FLOP TO A30-A TO FORM A PULSE OUTPUT. THE DURATION OF THE PULSE IS CONTROLLED BY THE TIME REQUIRED FOR R16, R17, AND A30-A TO RECHARGE C8 AND C9 SUFFICIENTLY TO RETURN BOTH A30-A INPUTS TO HIGH'S. I-INV-2 AND I-INV-3 INVERT THE ADVANCE KEY PULSE FROM A30-A TO FORM THE TWO NEGATIVE GOING DATA STROBE PULSES.

Figure C-32. Segmented Text. Text written as a series of short statements in which the theme in each statement does not necessarily relate to that in the following statement.

INDEX

79236-42

Figure C-33. Retrieval-Oriented List. A list provided to aid the reader in locating information in the document, e.g., tables of contents, lists of illustrations, and indexes.

GLOSSARY

Special computer terms and their specific meanings as applied to this computer are given below.

ABORT—The condition in the computer that results in the skipping of the next sequential instruction.

ACCESS TIME—The time interval, characteristics of a memory or storage device, between the instant information is requested from memory and the instant the next request for information from memory can be made.

ACKNOWLEDGE—Indication of the status of data on the input/output lines. Abbreviated as ACK.

ADDRESS—A coded number that specifically designates a computer register or other internal storage location. Information is referenced by its address. Portions of computer control are responsible for directing information to or from an addressed location.

ADDRESSABLE—Capable of being referenced by an instruction; e.g., Enter A (f = 11).

ARITHMETIC—A section within the computer where reasonable processes such as addition, subtraction, multiplication, and division are performed, and operands and results are stored temporarily.

BIT PLANE—Two memory boards that contain the same relative bit position for each of 32,768 memory locations. Bit position is defined by the associated stage in the Z register. Bit plane control is 'concerned with the parallel transmission (flow) of information into and out of memory on a bit plane level.

BOOTSTRAP—A routine, normally input, contained in the 16-word wired memory.

BORROW—A borrow in subtraction is the additional subtraction of a one from the next partial difference and is initiated when a digit of the minuend is zero and the corresponding digit of the subtrahend is one. In a binary system of modules $2^k - 1$, where k is the number of stages in a register, the borrow produced from the leftmost digit $2^k - 1$ of the minuend is called the end-around borrow. A final correction is made by applying the end-around borrow to the partial difference of the rightmost digits.

BRANCH POINT—A point in a program or instruction where a decision is made on the basis of arithmetic results. The result of the decision indicates whether the main program is to be continued or branched to a different program. See also JUMP.

79236-43

Figure C-34. Glossary/Abbreviations. A list of definitions of unfamiliar words, abbreviations, acronyms, symbols, or other unique items.

BEST AVAILABLE COPY

79236-44

Reference Designation	Name and Description
U16	Integrated Circuit: MFR 15238, P/N MIC962-5D
U17	Same as 3A1A1U2
U18	Same as 3A1A1U12
U19	Crystal Oscillator: MFR 14986, P/N UQ6C19.2K-BL-5
U20 to U23	Same as 3A1A1U1
U24	Same as 3A1A1U2
3A1A2	M/DU Control: MFR 14304, P/N 0240-5410
C1, C2	Capacitor, Fixed Tantalum, 39 uF, 10V: Mil type M39003/01-2019
C3	Capacitor, Electric, 10 uF, 16V: MFR 56289, P/N TE1155
CR1	Diode: Mil type 1N3611
R1	Resistor, Fixed Composition, 47K: Mil type RCR07G474JR
R2	Resistor, Fixed Composition, 18K: Mil type RCR07GF183JR
U1	Integrated Circuit: MFR 15238, P/N MIC946-5D
U2	Integrated Circuit: MFR 04713, P/N MC1810L
U3	Integrated Circuit: MFR 01295, P/N SN7496J
U4	Integrated Circuit: MFR 15238, P/N MIC934-5D
U5	Integrated Circuit: MFR 01295 P/N SN7493J
U6	Integrated Circuit: MFR 15238, P/N MIC945-5D

Figure C-35. Materials List. A list of parts, tools, controls, displays, test equipment, or other set(s) of items used in operating or maintaining equipment.

BEST AVAILABLE COPY

79246-45

AREA	FROM CONN	PIN	AREA	TO CONN		PIN	FUNCT UNIT		SIGNAL
J	005	039	05	XA	043	052	XD		KEYALPH
J	005	040	05	XA	043	075	XD		KEYCLR
J	005	041	02	XA	034	045	XD		CPCCLR
J	005	048	05	XA	037	006	M		DSTRBD1
J	005	049	05	XA	037	005	M	R	DSTRBD1
J	005	050	05	XA	037	E3	M	*	DSTRBD1
J	005	051	05	XA	037	017	M		DSTRBD2
J	005	052	05	XA	037	016	M	R	DSTRBD2
J	005	053	05	XA	037	021	M		DSTRBD3
J	005	054	05	XA	037	020	M	R	DSTRBD3
J	005	055	05	XA	037	049	M	*	DSTRBD3
J	005	056	05	XA	037	008	M		DSTRBD4
J	005	057	05	XA	037	007	M	R	DSTRBD4
J	005	058	05	XA	037	019	M		DSTRBD5
J	005	059	05	XA	037	018	M	R	DSTRBD5
J	005	060	05	XA	037	047	M	*	DSTRBD5
J	005	062	05	XA	037	045	M	*	DSTRBD2
J	005	063	05	XA	037	012	M		DSTRBD6
J	005	064	05	XA	037	011	M	R	DSTRBD6
J	005	065	05	XA	037	043	M	*	DSTRBD6
J	005	067	05	XA	037	037	M	*	DSTRBD4
J	005	068	05	XA	037	023	M		DSTRBD7
J	005	069	05	XA	037	022	M	R	DSTRBD7
J	005	070	05	XA	037	051	M	*	DSTRBD7
J	005	071	05	XA	037	010	M		DSTRBD8
J	005	072	05	XA	037	009	M	R	DSTRBD8
J	005	073	05	XA	037	041	M	*	DSTRBD8
J	005	080	05	XA	043	036	XD		PRVIDEO
J	005	081	05	XA	043	050	XD		DNLOC
J	005	082	05	XA	043	035	XD		HOSTFND
J	005	083	05	XA	037	032	XD		WLUOFF
J	005	084	05	XA	043	076	XD		REFHILO
J	005	085	05	XA	043	058	XD		PCOARSE
J	005	086	05	XA	035	032	XD		WLINE
J	005	088	05	XA	043	061	XD		PUSFINE
J	005	089	05	XA	043	048	XD		MCOARSE
J	005	090	05	XA	043	028	XD		6-12HND
J	005	091	05	XA	043	022	XD		MINFINE
J	005	092	05	XA	043	057	XD		MHADJ
J	005	093	05	XA	043	018	XD		SGLDBL
J	005	094	05	XA	043	021	XD		PZONE

Figure C-36. Wire List. A list of wiring connections for point-to-point wire checking, listing origin of signal, location of connection, and destination of output in a simple coded format.

Step	Operation of Test Equipment	Point of Test	Control Settings and Operation of Equipment	Performance Standards
3	...	SIF-P/SIF UNIQUE readout	a. Set NED thumb-wheels to 11111 b. Press ENTER 3 pushbutton c. Momentarily press READOUT 3 pushbutton d. Press ENTER 3 pushbutton off	SIF-P/UNIQUE readout shall display 11111
4	...	SIF-P/SIF UNIQUE readout	a. Set NED thumb-wheels to 14444 b. Press ENTER 4 pushbutton c. Momentarily press READOUT 4 pushbutton d. Press ENTER 4 pushbutton off	SIF-P/UNIQUE readout shall display 14444
5	...	SIF-P/SIF UNIQUE readout	a. Set NED thumb-wheels to 25555 b. Press ENTER 5 pushbutton c. Momentarily press READOUT 5 pushbutton d. Press ENTER 5 pushbutton off	SIF-P/UNIQUE readout shall display 25555

79236-46

Figure C-37. Procedures Table. A tabular format used to organize procedures into a logical sequence. Reference data in the table are usually organized in columnar form.

79236-47

Table 6-1. —Characteristics of mobile electric powerplants.

Type	Methods of propulsion	Generator drive	Operating environment	Power ratings		Starting Power		Service power	
				d. c.	a. c.	Jet	Recip.	Jet	Recip.
NC-5, NC-5A, NC-5B	Self-propelled gasoline engine vehicle	Main vehicle engine	Shore based only	28/35v 200/500a 1000a int	115/200v 400 Hz, 3ø 30/45 kva	d. c. only	d. c. only	a. c. d. c.	a. c. d. c.
NC-6, NC-6A	Towed trailer	Gasoline engine	Shore based only	28.5v 200a 32/45 kw	120/208v 400 Hz, 3ø 30 kva	DNA	DNA	a. c. d. c.	a. c. d. c.
NC-7, NC-7A, NC-7B, NC-7C	Towed trailer, or self-propelled within narrow limits	Gasoline engine	Shore based only	28.5v 750a 1000a int 45 kw	115/200v 400 Hz, 3ø 35 kva 0.75 PF	d. c. only	d. c. only	a. c. d. c.	a. c. d. c.
NC-10	Towed trailer	Diesel engine	Shore or carrier based	28v 750a 1000a int	115/200v 400 Hz 90 kva	d. c. only	d. c. only	a. c. d. c.	a. c. d. c.
NC-10A	Towed trailer or self-propelled	(same)	(same)	(same)	(same)	(same)	(same)	(same)	(same)
NC-12	Towed trailer	Diesel engine	Shore based only	28v 750a 1000a int 45 kw	115/200v 400 Hz 125 kva	d. c. only	d. c. only	a. c. d. c.	a. c. d. c.
NC-12A	(same)	(same)	Shore or carrier based	(same)	(same)	(same)	(same)	(same)	(same)

Figure C-38. Specialized Data Table. Information condensed into a table pertaining to a specialized area of knowledge. Tabular formats have one primary axis (column or row headings) while matrices use two axes in order to locate a cell containing the desired information. As a result, cells in matrices are more likely to contain numbers and symbols, while cells in tables are more likely to contain words.

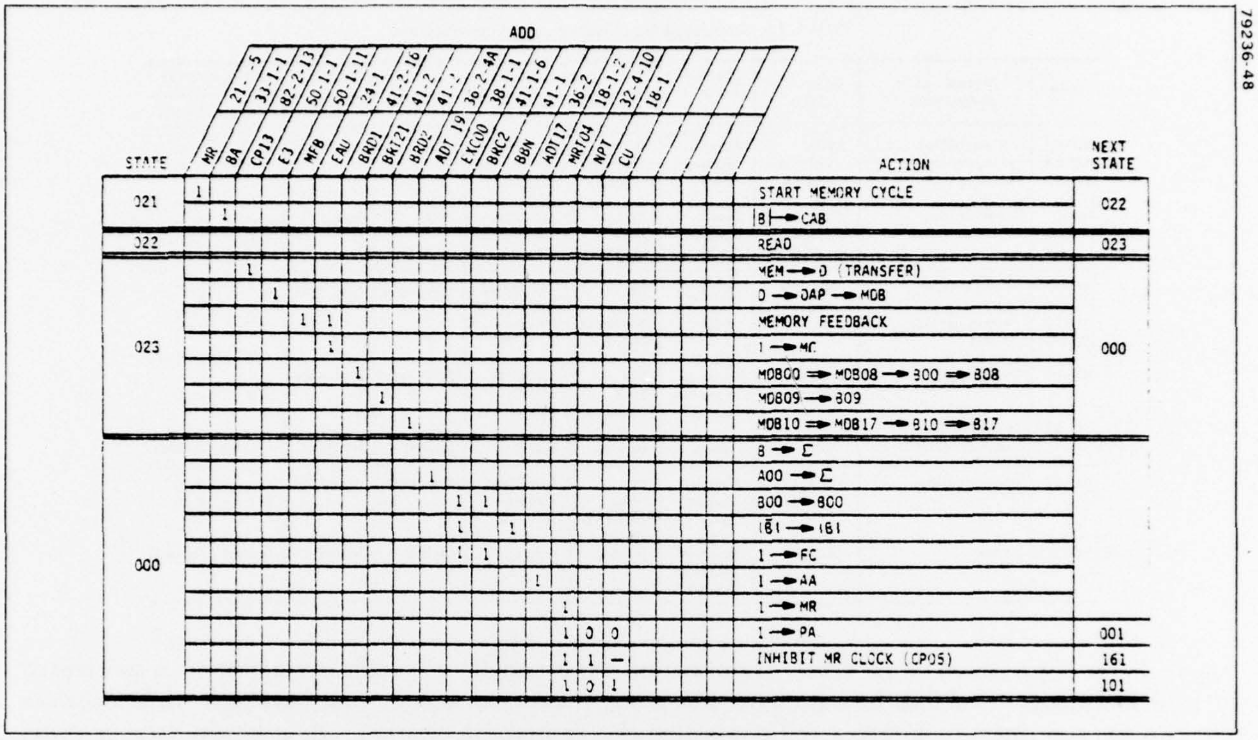


Figure C-39. Specialized Data Matrix. Information condensed into a matrix pertaining to a specialized area of knowledge. Tabular formats have one primary axis (column or row headings) while matrices use two axes in order to locate a cell containing the desired information. As a result, cells in matrices are more likely to contain numbers and symbols, while cells in tables are more likely to contain words.

DESCRIPTION		FUNCTIONAL INDEX				
	PAGE NO.	FUNCTIONAL BLOCK DIAGRAM PAGE NO.	FUNCTIONAL BLOCK DIAGRAM TEXT PAGE NO.	SCHEMATIC DIAGRAM PAGE NO.	SCHEMATIC DIAGRAM TEXT PAGE NO.	MDC OR MAINTENANCE DATA PAGE NO.
INDEX, EXPLANATION OF CODES, SHADES, SYMBOL	2	—	—	—	—	—
MANUAL DESCRIPTION	3	—	—	—	—	—
INTEGRATED CIRCUIT DATA	4	—	—	—	—	—
HOW TO USE MDC'S	6	—	—	—	—	—
EQUIPMENT DESCRIPTION	8	—	—	—	—	—
OPERATORS DATA	10	—	—	—	—	—
FUNCTION DESCRIPTION	—	15	14	—	—	—
SYSTEM LEVEL MDC	—	—	—	—	—	16, 17
POWER DISTRIBUTION	—	19	18	—	—	18
SYNCHRONIZER FUNCTION	—	21	20	—	—	22, 23
TRANSMIT FUNCTION	—	25	24	—	—	26, 27
RECEIVE-RECORD FUNCTION	—	29	28	—	—	30, 31
DIGITAL DISPLAY FUNCTION	—	33	32	—	—	34, 35
DIGITAL TO ANALOG CONVERTER FUNCTION	—	37	36	—	—	36
REMOTE INDICATOR FUNCTION	—	81	80	81	80	83
UNIT 1 RECEIVER-TRANSMITTER RT-888/UQN-4	—	—	—	—	—	—
1A1 ENERGY STORAGE ASSY	—	25	24	43	43	42
1A2 ENERGY STORAGE ASSY	—	25	24	43	43	42
1A3 POWER CHASSIS	—	19, 25, 29	18, 24, 28	43	43	42
1A4 CARD FILE	—		—	—	—	—
1A4A1 RECEIVER ASSY	—	29	28	45	45	44
1A4A2 RECEIVER CONTROL ASSY	—	29	28	47	47	46
1A4A3 REFERENCE ASSY	—	21, 25, 29, 33	20, 24, 28, 32	49	48	50, 51
1A4A4 SYNCHRONIZER ASSY	—	21	20	53	52	54, 55
1A4A5 KEYING CONTROL ASSY	—	25	24	57	56	58, 59
1A4A6 TRACKING CONTROL ASSY	—	33	32	61	60	62, 63
1A4A7 TRACKING CONTROL ASSY	—	33	32	61	60	62, 63
1A4A8 READOUT CONTROL ASSY	—	33	32	65	64	66, 67
1A4A9 READOUT CONTROL ASSY	—	33	32	65	64	66, 67
1A4A10 SLAVE READOUT BUFFER	—	33	32	69	68	68
1A4A11 T-R NETWORK	—	25, 29	24, 28	43	43	42
1A4A13 SIGNAL PROCESSOR	—	21, 25, 29	20, 24, 28	71	70	70

79236-49

Figure C-40. Retrieval-Oriented Matrix. A matrix provided to aid the reader in locating information in the document. Information on two axes is used to locate cells containing page, paragraph, or section numbers.